D-1 Wildlife
1988

HABITAT USE BY
THREE-TOED AND BLACK-BACKED WOODPECKERS,
DESCHUTES NATIONAL FOREST, OREGON

HABITAT USE BY THREE-TOED AND BLACK-BACKED WOODPECKERS, DESCHUTES NATIONAL FOREST, OREGON

by

Rebecca Goggans, Rita D. Dixon, and L. Claire Seminara

Nongame Project Number 87-3-02
Oregon Department of Fish and Wildlife
U.S.D.A. Deschutes National Forest

ABSTRACT

Patterns of habitat use for home ranges, foraging, nesting, and roosting, were described for three-toed (Picoides tridactylus) and black-backed (Picoides arcticus) woodpeckers on the Deschutes National Forest, Oregon, during April-September, 1986 and 1987. A severe mountain pine beetle epidemic had created an abundance of dead and dying trees, and an agressive pest management and timber salvage program had created a patchwork of logged areas, primarily shelterwood cuts, on the study area.

All nests excavated by three-toed and black-backed woodpeckers were in portions of lodgepole pine (Pinus contorta) trees with heartrot. Evidently, both species require soft wood for excavating cavities, because of morphological adaptations associated with 3 toes on each foot. Habitat selection for mature and overmature forest stands, and against younger stands and logged areas, was documented for three-toed woodpeckers using 16 nests, 493 forage bouts, and 16 roosts, and for black-backed woodpeckers using 35 nests, 395 forage bouts, and 20 roosts. Home range sizes for 3 radio-tagged three-toed woodpeckers were 751, 351, and 131 acres (n=170, 352, and 131 locations, respectively). Home range sizes for 3 radio-tagged black-backed woodpeckers were 810, 303, and 178 acres (n= 124, 86 and 112 locations, respectively). Intra-specific home range overlap among both species appeared limited or nonexistent, except among paired individuals near the nest site. Inter-specific home range overlap was common between three-toed and black-backed woodpeckers and other Picidae.

Guidelines for management included establishing Management Areas which retain the characteristics of mature and overmature lodgepole pine or lodgepole pine-mixed conifer forest stands. Recommended sizes of Management Areas were 528 acres per pair of three-toed woodpeckers, at a minimum elevation of 4500 ft, and 956 acres per pair of black-backed woodpeckers, with some Areas at elevations less than 4500 ft. One Management Area could be designated for both species, if the respective habitat needs were met.

SUMMARY

INTRODUCTION

Three-toed and black-backed woodpeckers are two of the least known species of woodpeckers in North America. They are sympatric over most of their North American range and both are nonmigratory residents on the east slope of the Cascade Mountain Range. The woodpeckers are associated with trees characterized by scaly or flaky bark, but differ in the species of trees with which they are associated; the three-toed woodpecker is more closely associated with spruce (Picea spp.), and the black-backed woodpecker with pine (Pinus spp.).

The three-toed and black-backed woodpeckers are distinguished from all other woodpeckers by an adaptive complex that includes 3 toes on each foot, instead of the usual 4. This complex specializes these species for delivering hard blows, but at the expense of "smooth" climbing ability. Wood-boring insects (Cerambycidae and Buprestidae) are an efficient food source for three-toed and black-backed woodpeckers because, where habitat is appropriate, they are abundant in small areas, thus can be exploited using hard blows but little climbing. Abundance of wood-boring insects increase as a forest stand matures and eventually overmatures because the growth and vigor of trees decline, and the number and diameter of dead and dying trees increase.

Most of the lodgepole pine stands on the east slope of the Cascade Mountain Range in Oregon are in a mature and overmature condition, thus are susceptible to attacks by bark beetles. On the Deschutes National Forest, a bark beetle epidemic began during the early 1970's, and by 1987, 50% of the lodgepole pine timber volume was dead. This mortality was unevenly distributed across the range of stem sizes; most of the larger trees were dead, while most of the smaller trees were alive. The level of future mortality is difficult to predict.

Bark beetle outbreaks are recurrent in lodgepole pine types, and occur about 30-40 years apart. How have three-toed and black-backed woodpeckers, which likely evolved under conditions of recurrent outbreaks, survived numerous fluctuations in food supply? Tree-killing during outbreaks is patchy, varying in intensity, thus stands recovering from outbreaks show considerable variability in age and structure. Although the forest structure may be altered drastically, the key components remain, albeit in reduced abundance; trees which survive provide prey and habitat for three-toed and black-backed woodpeckers;

An aggressive pest management program on the Deschutes National Forest has led to extensive and intensive harvest of lodgepole pine stands. The current program calls for continued thinning in the future. The result will be an even-aged, widely-spaced, vigorous forest, which is highly resistant to beetles, and to other forms of mortality and decay. In effect, key components of the lodgepole pine ecosystem, such as heartrot and other forms of disease, are being eliminated. The effects on wildlife are little known, but may be negative for species which evolved under other conditions.

The Code of Federal Regulations (36 CFR 219.9) requires each National Forest to provide habitat to support, at least, a minimum number of reproductive individuals of each species. This study was initiated during the spring of 1986. The initial effort (May-July) was exploratory, primarily to develop techniques for finding and working with the woodpeckers, and to locate populations of sufficient size for further study. During April- September, 1987, we conducted an intensive study of patterns of habitat use by three-toed and black-backed woodpeckers. The objectives were to describe habitat used for home ranges, nesting, foraging, and roosting, in logged and unlogged areas, in lodgepole pine forests characteristic of the east slope of the Cascade Mountain Range in Oregon.

STUDY AREAS

The upper study area, 13.4 square miles ranging from 4500 to 5400 ft elevation, was selected for its suitability as habitat for three-toed woodpeckers, but also provided suitable habitat for black-backed woodpeckers. Forest stands were mixed conifer interspersed with stands of pure lodgepole pine. Logged areas were 28% of the study area and unlogged areas, 72%.

The lower study area, 11.9 square miles ranging from 4350 to 4430 feet elevation, was selected for its suitability as habitat for black-backed woodpeckers. Forest stands were primarily pure lodgepole pine. Logged areas were 38% of the study area and unlogged areas, 62%. Silvicultural treatments were typically shelterwood cuts converted to a stocking of approximately 30 trees/acre, prior to overstory removal.

RESULTS

THREE-TOED WOODPECKERS

Three-toed woodpeckers were located by playing a recording of species-specific drumming at frequent intervals (≈0.1 mi). Although this survey technique may not detect all woodpeckers, it appeared suitable for monitoring long-term fluctuations in population abundance. Responsiveness to recordings appeared to coincide with initiation of cavity excavation and responsiveness ceased when egg-laying began, a period of approximtely 3 weeks. Elevation, and annual variations in climatic conditions, influenced timing of breeding, and correspondingly affected timing of responsiveness. The most effective survey period for 5000-5500 ft elevation was between 7 May and 7 June. We estimated a delay in breeding condition of 4-6 days/≈500 ft gain in elevation, thus surveys at 4500 ft would generally be most effective around the first of May, and surveys at 6000 ft elevation would be most effective around the middle of May. Responsiveness began approximately 1/2 h after sunrise, peaked between 1-2 h after sunrise, and declined up to 5 h after sunrise, after which responses became rare. Woodpeckers usually responded to recordings within 3 minutes. Non-motorized transportation was more effective for surveys than motorized transportation because of increased opportunity to hear woodpeckers.

Home range sizes for 3 radio-tagged three-toed woodpeckers were 751, 351, and 131 acres, estimated from 170, 352, and 131 locations, respectively. Sizes of home ranges appeared to be related to number of radio-telemetry locations, indicating that for the smaller home ranges, data may have been inadequate. Utilization-availability analyses for home ranges showed that, within the study area, mature and overmature forest stands were selected, and younger stands and logged areas were avoided. Selection for forest type was not apparent. Intra-specific home range overlap appeared limited or nonexistent, except among paired individuals near the nest site. Inter-specific home range overlap was common between three-toed woodpeckers and other Picidae, including the black-backed woodpecker.

Twenty nests were located; 16 were on, or near, the upper study area, and 4 were located outside either study area. Utilization-availability analyses showed lodgepole pine stands were selected for nesting, and mixed conifer stands were avoided. Use of logged areas was similar to availability. Mean stem size at nest sites was 8.0 in diameter at breast height (dbh). Percent log cover was 17. Mean canopy closure for nests in uncut stands was 27%, and for nests in cut stands, 18%. Mean basal area for nests in uncut stands was 139 ft^2/acre, and for nests in cut stands, 72 ft^2/acre. All nests were in lodgepole pine trees; 15 nest trees were dead and 5 were live. Of the dead nest trees, 11 were Stage 2 (hard; needles absent and limbs present but broken). Mean dbh of nest trees was 11.0 in. All nest cavities were apparently excavated in portions of the nest trees with heartrot; because of morphological adaptations associated with 3 toes on each foot, instead of the usual 4, three-toed woodpeckers require soft heartwood for excavating cavities.

Foraging habitat was documented during 493 bouts. Mature and overmature stands were selected for foraging, and younger stands and logged areas were avoided. Selection for forest type was not detected. Lodgepole pine trees were used during 63% of the foraging observations, and Engelmann spruce (Picea engelmannii) during 25%. Dead trees were used during 88% of the observations, but only 52% of all trees used were infested with mountain pine beetles. Mean dbh of all trees used for foraging was 15.5 in, and mean dbh of all lodgepole pine trees used for foraging was 11.5 in. The mean number of stems per acre, for all trees greater than 4 in dbh, was 503. Mean dbh for forage stands was 10.0 in. Mean basal area for mixed conifer stands was 363 ft^2/acre, for mixed conifer dominated by lodgepole pine, 372 ft^2/acre, and for lodgepole pine stands, 182 ft^2/acre.

Sixteen roost trees, used for 26 nights by 5 radio-tagged three-toed woodpeckers, were located. Fourteen roosts were in cavities, 1 was under bark peeling from a tree trunk, and one location was not determined. Mature and overmature stands were selected for roosts; young stands or logged areas were avoided. Forest types selected were mountain hemlock and mixed conifer; lodgepole pine forest type was avoided. Mean dbh of trees in roost stands was 9.0 in. Mean canopy closure was 44%. Mean basal area of roost stands was 193 ft^2/acre. Tree species used for roosts varied, but all roost trees were dead and 11 were decayed (Stage 3 or 4 snags). Mean dbh of roost trees was 12.0 in. Mean tree height was 35 ft.

RESULTS

BLACK-BACKED WOODPECKERS

Black-backed woodpeckers responded to play-back recordings of species-specific drumming, usually within 3 minutes. In general, black-backed woodpeckers were more responsive than three-toed woodpeckers. Responsiveness to play-back recordings increased as woodpeckers approached egg-laying and declined when incubation began, but continued throughout the summer, to some extent. Annual variations in climatic conditions and elevation, which influenced timing of breeding, correspondingly affected timing of responsiveness. The most effective survey period for 4300-4400 ft elevation was between 1 May and 1 June. We estimated a delay in breeding condition of 4-6 days/≈500 ft gain in elevation, thus surveys at 4300 ft would be most effective around the first of May, and surveys at 5300 ft elevation would be most effective around the middle of May. Responses began approximately 1/2 h after sunrise and peaked between 1-2 h later, but could be elicited throughout the day with varying consistency. Non-motorized transportation was more effective for surveys than motorized transportation, because of increased opportunity to hear woodpeckers. Although this technique may not detect all woodpeckers, it appeared suitable for monitoring long-term fluctuations in population abundance.

Home range sizes for 3 black-backed woodpeckers were 810, 303, and 178 acres, estimated from 124, 86 and 112 locations, respectively. Sizes of home ranges appeared to be related to number of radio-telemetry locations, indicating that for the smaller home ranges, data may have been inadequate. Estimated sizes of home ranges appeared to be related to the proportions of unlogged areas within the home ranges; that is, the largest home range had the smallest proportion of unlogged habitat. Utilization-availability analyses showed that, all woodpeckers selected for mature and overmature forest stands, and selected against younger forest stands and logged areas. Intra-specific home range overlap appeared limited or nonexistent, except among paired individuals near the nest site. Inter-specific home range overlap was common between black-backed woodpeckers and other Picidae, including the three-toed woodpecker.

Thirty-five nests used by black-backed woodpeckers were located: 13 on the upper study area, 9 on the lower study area and 13 on neither study area. Only nests located on one of the study areas were used to evaluate habitat selection. Mature and overmature forest stands were selected on the lower study area; young stands and logged areas were avoided. Selection for forest type was not measured on the lower study area because only lodgepole pine forest type was available. Selection for habitat or forest type was not detected on the upper study area. Use of logged areas for nesting was similar to availability, on both study areas. Mean stem size at nest sites was 8.0 in dbh. Percent log cover was 13. Mean basal area for nests in lodgepole pine was 79 ft^2/acre, and for nests in mixed conifer dominated by lodgepole pine, 136 ft^2/acre. Mean basal area for uncut stands was 112 ft^2/acre, for nests in fuel cut stands, 79 ft^2/acre, and for nests in partial cut or shelterwood stands, 34 ft^2/acre. Mean canopy closure for nests in uncut stands was 24%, and for nests in cut stands, 11%. All nests were in lodgepole pine trees; 23 nest trees were live and 12 were dead. The mean dbh of nest trees was 11.0 in. All nest cavities appeared to be excavated in portions of the nest trees with heartrot. Because of morphological adaptations associated with 3 toes on each foot, instead of the usual 4, black-backed woodpeckers require soft wood for excavating cavities.

Foraging habitat was documented during 395 bouts. Mature and overmature stands were on the lower study area; younger stands or logged areas were avoided. Lodgepole pine trees were used during 97% of the foraging observations. Dead trees were used during 68% of the observations, but 81% of all trees used were infested with mountain pine beetles. Mean dbh of all trees used for foraging was 15.0 in, and mean dbh of all lodgepole pine trees used for foraging was 14.0 in. The mean number of stems per acre, for all trees greater than 4.0 in dbh, was 503. Mean dbh for forage stands was 10.0 in. Mean basal area for mixed conifer stands was 363 ft^2/acre, for mixed conifer dominated by lodgepole pine, 413 ft^2/acre, and for lodgepole pine stands, 411 ft^2/acre.

Twenty roost trees, used for 24 nights, by 4 radio-tagged black-backed woodpeckers, were located. None of the roosts were in cavities; 4 roosts were in concave western gall rust cankers, 2 roosts were in deep trunk scars, 2 roosts were on the trunk, 1 was where a branch forked, creating an indentation in the trunk, 1 was in a mistletoe clump, and 10 were not determined. Mature and overmature stands were selected for roosts. Selection for forest type was not measured because most roosts were on the lower study area where only lodgepole pine forest type was available. Mean canopy closure at roost sites was 40%. Mean dbh of trees in the roost stand was 6.0 in. Mean basal area of roost stands was 115 ft^2/acre. Lodgepole pine trees were used for 14 roosts. Mean dbh of roost trees was 11.0 in. Mean tree height was 65 ft.

MANAGEMENT IMPLICATIONS

Mature and overmature forest stands have a high incidence of disease, decay and mortality. Trees with disease and decay are undesirable components of a managed forest, but were used by three-toed and black-backed woodpeckers for home range, nesting, roosting, and foraging habitat. Nests were excavated in trees with heartrot, roosts were in diseased portions of trees or decayed snags, and forage sites were in mature and overmature stands, which have abundant disease and decay, and consequently abundant wood-boring insects. Conversion to and maintenance of lodgepole pine and lodgepole pine-dominated mixed conifer stands in a young, vigorous condition may eliminate or severely restrict incidence of wood-boring insects and heartrot, leading to declines in populations of three-toed and black-backed woodpecker.

Acreage of mature and overmature lodgepole pine forest stands are declining throughout the Oregon Cascades, because these stands are the prime target of the mountain pine beetle. Stands which experience high mortality nonetheless provide habitat for three-toed and black-backed woodpeckers. Individual trees within a stand may remain standing 10, 15 or 20 years, thus providing a continuum of habitat. Treating these stands, by logging, immediately converts them to a vigorous condition where incidence of death and decay is severely restricted, thus potential nesting and foraging substrate is drastically reduced. Although in time, stands without treatment may be structurally similar to treated stands, the time to reach that condition differs significantly. Because stands without treatment continue to provide habitat over a longer time than treated stands, thus there is a shorter period when old growth lodgepole pine is absent or scarce on the Deschutes or other National Forests. Consequently, a larger population of woodpeckers may survive, thereby increasing the potential for maintening viable populations of both species.

Designation of the three-toed woodpecker as an Indicator Species for mature and old growth lodgepole pine appeared appropriate, but only at elevations greater than 4500 ft. Much of the pure lodgepole pine on the east slope of the Cascade Mountain Range in Oregon occurs at elevations less than 4500 ft. We recommended the black-backed woodpecker as an Indicator Species for mature and old growth lodgepole pine, instead of the three-toed woodpecker. Unlike the three-toed woodpecker, the black-backed woodpecker used a range of elevations coincident with lodgepole pine. Futher, it responded to play-back recordings more frequently, over a longer time period, and with louder vocalizations than the three-toed woodpecker, thus may be more effectively monitored than the three-toed woodpecker.

Until more information is available, we believe the most effective method of insuring habitat for three-toed and black-backed woodpeckers is to exempt areas (i.e. Woodpecker Management Areas) from commercial or salvage timber management and place these areas under a special management strategy, which retains the characteristics of mature or overmature lodgepole pine habitat as long as possible, without treatment. Woodpecker Management Areas should be in lodgepole pine or lodgepole pine-dominated stands with the greatest probability of surviving the longest time, but if these stands no longer retain the characteristics of mature and overmature stands, or if the number of trees remaining is inadequate to support a pair of woodpeckers, then the designated Woodpecker Management Area should be relocated to a selected replacement. Replacement stands should be selected now, to provide the earliest possible replacement for declining Woodpecker Management Areas. Woodpecker Management Areas, and replacement areas, may be within areas previously designated as protected, such as old-growth areas, Spotted Owl Habitat Areas, winter recreation sites, Research Natural Areas, etc. Management Areas for each pair of three-toed woodpeckers should be 528 acres of lodgepole pine or mixed conifer forest in mature and overmature condition and at an elevation of 4500 ft or higher. Management Areas for each pair of black-backed woodpeckers should be 956 acres of lodgepole pine or lodgepole pine-dominated mixed conifer forest in mature and overmature condition. One Management Area of 956 acres, at an elevation of

4500 ft or higher, could be designated for 1 pair of both species. However, Management Areas for black-backed woodpeckers should not be restricted to elevations greater than 4500 ft because this species may be better adapted to conditions at lower elevations.

Black-backed woodpeckers are not currently assigned a special status (e.g. Indicator Species), thus designation of Woodpecker Management Areas may not be practical at this time. An alternative management strategy can be applied on a sale-by-sale basis. On each sale, habitat can be preserved for each pair of black-backed woodpeckers by removing 956 acres of inter-connected blocks of mature/overmature habitat from harvest. For example, if a sale area is 9500 acres of mature or overmature lodgepole pine-dominated habitat, management at 60% of potential would be for 6 pairs, or 6 areas of 950 acres each. The traditional approach for management of cavity-nesters at 60% of potential by retaining 60% of the snags and live replacement tree may be ineffective for black-backed and three-toed woodpeckers for two reasons. One - snags provide more than nesting habitat; snag retention at the 60% level is unlikely to occur in sufficient amounts to provide adequate feeding substrate for species dependent on wood-boring insects associated with trees with flaky/scaly bark. Two - this approach addresses a singular, albeit a key, component of the species' habitat. The interrelationships of an old growth, or mature/overmature ecosystem, and the species associated with it, are little known, but likely complex. Land managers do not, at this time, have the information necessary to manipulate habitat and insure these interrelationships will be maintained.

The figures for home range sizes and the amount of mature or overmature stands used by woodpeckers were estimated under conditions of abundant food supply. As the mountain pine beetle epidemic runs its course, and prey abundance declines, it is likely that the amount of area required to support a pair of three-toed or black-backed woodpecker will increase.

Three-toed and black-backed woodpeckers should be monitored to track changes in population levels as the mountain pine beetle epidemic runs its course and as the forest becomes increasingly managed, resulting in reduced levels of disease and decay. Survey routes to document number of woodpecker responses should be monitored annually. Population levels of three-toed and black-backed woodpeckers prior to the mountain pine beetle epidemic were undocumented, thus the effects of the mountain pine beetle epidemic on population levels is unknown. A review of population irruptions by three-toed and black-backed woodpeckers in eastern North America suggested that numbers of black-backed woodpeckers increase with increasing prey abundance, but that populations of three-toed woodpeckers are much less responsive to changes in prey abundance. It is possible that numbers of black-backed woodpeckers increased as the density of mountain pine beetles increased on the Deschutes National Forest. Similarly, populations may decline as the epidemic runs its course and prey for the woodpeckers becomes scarcer. It may be difficult to distinquish between the effects of the epidemic, and of timber management to control the epidemic, on populations of black-backed and three-toed woodpeckers. Documenting breeding success in Management Areas may be an effective method of combatting public outcry if woodpecker populations decline on the Forest.

This study provides a preliminary data base on habitat use by three-toed and black-backed woodpeckers; it is intended as a springboard for other studies. The pioneering nature of the study required a limited time frame, geographic scope, and sample size. Consequently, management recommendations represent the best available information at this point in time, but are intended to evolve as more information becomes available. Additional research should be a priority for land managers. Research needs include: (1) information on habitat use in areas without a bark beetle epidemic, (2) estimates for home range sizes of individuals of both species under a range of conditions, (3) estimates for breeding home range sizes of both species, (4) information on flexibility of the species to adjust to managed forest habitat, (5) information on the relationship of habitat quality and fragmentation to home range size, and (6) information on juvenile dispersal.

Literature citation:

Goggans, et al. 1988. Habitat use by three-toed and black-backed woodpeckers. ODFW Nongame Report 87-3-02. xvii + 49pp + 34 figures/tables.

Copies of this report available from:

Oregon Department of Fish and Wildlife
61374 Parrell Road
Bend, OR 97702

ACKNOWLEDGEMENTS

Ralph Opp and E. C. Meslow were instrumental in initiating this study. Don Pedersen, Ed Styskel and Kevin Martin provided key support in acquiring funds from the USDA Forest Service. Funding was provided by Oregon Department of Fish and Wildlife's Nongame Check-off Program and the Deschutes National Forest. Both Agencies contributed field housing and equipment, and the Fremont National Forest provided a radio receiver. Ed Styskel, Del Sanford and Norm Behrens provided advice and encouragement. Frank B. Isaacs, Gary Milano and Ted G. Wise donated extensive time during field work. Kate Boula assisted with literature searches. Special thanks to all of these contributors.

Jean and Bill Ward contributed an excellent recording of drumming by a three-toed woodpecker. Dr. Fred L. Ramsey, Dr. E. L. Bull, Robert H. Hudson, and David B. Marshall provided insight into the biology of three-toed woodpeckers. Kip Drobish provided excellent field assistance.

Volunteers played an important role in collecting field data. Thanks to Kathy Allard, John Dotson, Alice and Cal Elshoff, Richard Inman, Craig Miller, Frank Isaacs, Scott Lutz, Cate Paige, Alice Wilson, and Deborah and Glen VanCise. Equipment was generously loaned by Evie Bull, Kip Drobish, Cal Elshoff, Mark Henjum, Gary Milano, Kevin Martin, Chuck Meslow, Bill Otani, Karen Theodore, and Mitch Willis.

Many people, in addition to the above contributors, assisted in various aspects of this study. We thank all participants and contributors.

TABLE OF CONTENTS

Habitat Use
by Three-toed and Black-backed Woodpeckers, Deschutes National Forest, Oregon.

PART I
INTRODUCTION

Three-toed (Picoides tridactylus) and black-backed (Picoides arcticus) woodpeckers are two of the least known species of woodpeckers in North America. Both are nonmigratory residents on the east slope of the Cascade Mountain Range and both are affected by management on National Forest lands.

The species' are unique in that 3 toes are on each foot, instead of the usual 4. They are sympatric over most of their North American range and are associated with trees characterized by scaly or flaky bark. The woodpeckers differ in the species of trees with which they are associated; the three-toed woodpecker is more closely associated with spruce (Picea spp.), and the black-backed woodpecker, with pine (Pinus spp.) (Bock and Bock 1974). This is attributed, at least in part, to the evolution of these species. During Pleistocene glaciation, separate populations of a single species with 3 toes were geographically isolated: a pre-three-toed population in interior Alaska where spruce dominated, and a pre-black-backed population south of the ice cap where more diverse coniferous forests dominated. When the ice cap retreated, the ranges of the two newly evolved species expanded and overlapped in North America. The differences between the three-toed and black-backed woodpecker, and between these species and other species of woodpeckers, are important in understanding their functional use of the landscape, and consequently in planning management strategies.

Three-toed and black-backed woodpeckers are distinguished from all other woodpeckers by an adaptive complex that specializes them for delivering hard blows, but at the expense of "smooth" climbing ability; that is, woodpeckers with 3 toes use more energy in climbing than woodpeckers with 4 toes (Spring 1965). Thus, to maintain a positive energy balance, three-toed and black-backed woodpeckers must employ a pattern of feeding which minimizes vertical climbing, but exploits the ability to deliver hard blows. These characteristics constrain the woodpeckers to forage by excavating in wood, but require that high densities of insects occur where the woodpecker is excavating. As a forest stand matures and eventually overmatures, the growth and vigor of trees decline, and the number and diameter of dead and dying trees increase. Consequently, abundance of wood-boring insects increase (Bull 1986). Wood-boring insects (Cerambycidae and Buprestidae) are an efficient food source for three-toed and black-backed woodpeckers because, where habitat is appropriate, they are abundant in small areas.

Most of the lodgepole pine (Pinus contorta) stands on the east slope of the Cascade Mountain Range in Oregon are in a mature and overmature condition. These conditions are conducive to attacks by bark beetles (mountain pine beetle, Dendroctonus ponderosae; western pine beetle, Dendroctonus brevicomis ; Ips, Ips spp). A bark beetle epidemic began during the early 1970's on the Deschutes National Forest and peaked about 1984 in most areas. Of approximately 210,000 acres of mature and overmature lodgepole pine stands on the Deschutes National Forest, 75,000 acres had been regenerated or thinned and 135,000 acres infested with mountain pine beetle by 1987 (USDA Forest Service 1987). Fifty percent of the timber volume was already dead. This mortality was unevenly distributed across the range of stem sizes. Most of the larger trees were dead, while most of the smaller trees were alive. The level of future mortality is difficult to predict.

Bark beetle outbreaks are recurrent in lodgepole pine types, and occur about 30-40 years apart. During bark beetle outbreaks, tree mortality is extensive and wood-boring insects become abundant; associated species, such as three-toed and black-backed woodpeckers may also increase in abundance. Similarly, as a bark beetle outbreak runs its course, wood-boring insects decrease in abundance. How have three-toed and black-backed woodpeckers, which likely evolved under conditions of recurrent outbreaks, survived numerous fluctuations in food supply?

In natural stands, tree-killing during outbreaks is variable in intensity across the range of stem sizes. Scattered mature and overmature trees, and many young trees survive. These surviving trees provide prey and habitat for three-toed and black-backed woodpeckers. Because tree-killing during outbreaks is patchy and varies in intensity, stands recovering from outbreaks show considerable variability in age and structure (USDA Forest Service 1987). Mortality from a variety of causes continues. The bark beetle population stays at low levels between outbreaks, but susceptible trees scattered throughout the forest are attacked and killed; scattered localized outbreaks may develop now and then, killing patches of trees. Trees surviving the previous outbreak undergo natural mortality, or are killed by fires and windthrow during storms. Thus habitat for three-toed and black-backed woodpeckers remains during periods between insect outbreaks, though prey may be less abundant.

This pattern is being interrupted on the National Forests of Area 4. Virtually all of the habitat for maintaining populations of three-toed and black-backed woodpeckers during the "troughs" of the bark beetle-lodgepole pine "cycle" is scheduled for removal. An aggressive pest management program implemented on the Deschutes National Forest to combat the current epidemic and to salvage some economic value from the dying Forest has led to extensive and intensive harvest of lodgepole pine stands. Current planning calls for thinning most stands because thinning creates a response in vigor, which aids in beetle resistance. Thinning also reduces the spread of beetles because widely spaced trees provide an insuffcient food base to sustain epidemic beetle populations. Silvicultural prescriptions are generally for shelterwood cuts followed by overstory removal when regeneration is established. The current program calls for continued thinning in the future. The result will be an even-aged, widely-spaced, vigorous forest, which is highly resistant to beetles, and to other forms of mortality and decay. The effects of this, and the epidemic, on wildlife are little known, but may be severe for three-toed and black-backed woodpeckers which evolved under other conditions.

The Code of Federal Regulations (36 CFR 219.9) requires each National Forest to provide habitat to support, at least, a minimum number of reproductive individuals of each species. Little is known about the reproductive biology of three-toed and black-backed woodpeckers. Techniques to locate these species and to monitor population changes have not been developed. Reliable estimates for density and size of home ranges are not available. These are necessary in planning for and managing habitat to reduce the risk of population reduction below the required minimum viable population level.

The study was initiated during the spring of 1986. The initial effort (May-July) was exploratory, primarily to develop techniques for finding and working with the woodpeckers and to locate populations of sufficient size for further study. During April- September, 1987, we conducted an intensive study of habitat use by three-toed and black-backed woodpeckers. The objectives were to describe patterns of habitat used for home ranges, nesting, foraging, and roosting in unlogged and logged areas.

STUDY AREAS

The study was conducted on the east slope of the Cascade Mountain Range in the Deschutes National Forest, Oregon (Figure 1). Topography is gently sloping plateaus, dominated by scattered volcanic peaks and smaller "cinder cones" (Franklin and Dyrness 1973). Glacial streams and rivers dissect the Forest. The area is geologically young and soils are poorly developed. The climate is characterized by wide diurnal temperature fluctuations, especially during summer. Precipitation occurs primarily as snow, and frost is possible during any month.

During 1986, no study area was defined, but areas from Elk Lake south to Crescent Lake were searched for three-toed and black-backed woodpeckers. During 1987, two well-defined study areas were selected (Figure 2). Selection was based on (1) habitat representative of the east slope of the Cascade Mountain Range, (2) areas with a mixture of logged and unlogged habitat, and (3) sufficient densities of three-toed and black-backed woodpeckers. The upper study area was selected for its suitability as habitat for three-toed and black-backed woodpeckers; the lower study area for its suitability as habitat for black-backed woodpeckers. Both areas are described in detail in Parts II and III.

METHODS

Location of woodpeckers: Searches for woodpeckers, conducted primarily on foot, were initiated 1 April 1986 and 27 April 1987. A recording of territorial drumming by a three-toed or black-backed woodpecker was played at frequent intervals. When a woodpecker responded to the play-back recording , or when any sound characteristic of a foraging woodpecker was heard, we attempted to visually locate the bird. During 1986, search routes were selected to cover a variety of habitats. During 1987, routes were selected to intensively search each study area for all woodpeckers present.

Location of nests: Nests of three-toed and black-backed woodpeckers were located during two periods of the reproductive cycle. During the period when woodpeckers were excavating cavities, nests were located by following adults to the excavation site. During the period when nestlings were present, nests were located by following adults delivering food to the nest or, in 1987, by systematically walking both study areas and listening for the sound of nestlings begging for food. Nestlings of both species beg almost continuously and, as they near fledging, can be heard up to 300 ft.

Trapping: Breeding woodpeckers were trapped at or near nest cavities. To avoid nest abandonment, trapping was not initiated until hatchlings were present. Black-backed woodpeckers were trapped by stringing one or more mist nets near the nest cavity, in a flight path commonly used by adults delivering food to nestlings. Three-toed woodpeckers were caught occasionally by the previous method, but more commonly by placing a mist net "basket" over the entrance to the nest cavity when an adult was inside. Upon exiting, the adult would be caught in the net. Three-toed woodpeckers were re-trapped at roost cavities by the latter technique.

Radio-tagging: Woodpeckers were equipped with 150 mgh radio transmitters.

Transmitters were attached to the underside of one central tail retrix by a series of nylon ties extending along the feather shaft. Transmitters weighed less than 2 gm, had an operational life of about 30 days, and a range of about 1/4 mile.

Radiotelemetry data collection: Tracking was conducted with Telonics TR-2 receivers and hand-held 2-element Yagi antennas. Woodpeckers were monitored continuously during telemetry bouts. Telemetry locations were recorded at intervals not less than 10 minutes. Woodpeckers were verified visually for all locations, except some roost locations. Black-backed woodpeckers flushed readily from roosts, thus the actual roost location often went undetected. Most locations were of perched woodpeckers because of the difficulty in describing habitat used by a moving bird. For each location, a point-centered quarter plot (Mueller-Dombois and Ellenberg 1974), centered on the woodpecker, was used to record habitat characteristics. In addition, the date, time, activity of woodpecker, characteristics of the substrate used by the woodpecker, and additional characteristics of the forest stand were recorded. Six types of woodpecker activity were recognized: foraging, drumming, resting/preening, interacting with another animal, roosting and "other". Most locations were during foraging, because woodpeckers foraged most of the day. Substrates used by woodpeckers were characterized by position (standing or down), species, dbh, condition, and if dead, snag stage (Stage 1=needles and limbs present, Stage 2=needles absent, limbs and/or top broken, Stage 3=no limbs, Stage 4=decayed). Trees were considered live if green needles were present. Forest stands were characterized by type, management (uncut, fuelwood cut, partialcut, shelterwood cut, clearcut), canopy closure, and number of layers. Telemetry locations were field-marked with surveyor flagging on which a date and identification number were recorded. In September, after all radio tracking was completed, locations were plotted on maps scaled to 4 inches per mile. To accurately plot locations, roads were marked into 1/10 mile sections, and the distance from each flag was paced to the nearest road marker.

Estimation of home ranges: Home ranges can be calculated by statistical and non-statistical means. An assumption of statistical home range estimates is that locations are independent. Independence of locations is related to time between locations. The life of a radio-transmitter battery is determined by its size; the smaller the battery, the shorter the life. Because of weight limitations, life of batteries in this study was 30 days. Under such severe time restrictions, an adequate number of independent locations to estimate home ranges is impossible; thus the minimum convex polygon (Mohr 1947), a non-statistical, but standard, home range model, was used. No model can accurately describe the home range of an animal; models interpret lines where often none exists. Home range models are, nonetheless, one of the best tools to describe habitat for management purposes.

Evaluation of habitat selection by woodpeckers: Habitat selection has been defined as use of a habitat disproportionate to its availability (Johnson 1980). For this study, the level of use relative to availablility which signified selection was designated as 50% (Mellen 1987). Forest habitat classes used in a proportion 50% greater than expected, based on availability, were interpreted as selected for, and classes used in a proportion 50% less than expected were interpreted as selected against. U.S.D.A. Deschutes National Forest Total Resource Inventory System (TRI-System) maps were used to plot habitat acreages. Under the TRI-system, forests are subdivided into stands of relatively uniform character, assigned an identification number and coded by characteristics. Using a digitizer, the area encompassed by each TRI-System unit within the study areas was measured. The proportion of a study area which a particular stand characteristic comprised was compared to the proportion of locations, nests, or roosts, in stands with that particular characteristic. Selection was tested at 2 levels: selection within the defined home range, and selection within the study area.

Classification of forest habitats: Two types of TRI-system habitat classifications were applied. Initially, selection for forest structure relative to stand maturity was tested. The classes were (1) single-storied seedlings, saplings or immature poles, (2) single-storied small sawtimber, (3) single-storied mature and overmature sawtimber, (4) multi-storied viable and nonviable understory, and (5) plantations and cuts. Next selection for forest type was tested. The classes were (1) lodgepole pine and (2) mixed conifer. Ponderosa pine (Pinus ponderosae)/white fir and Engelmann spruce (Picea Engelmannii) forest types comprised 3% and 5% of the upper study area, respectively. These were included in the mixed conifer classification for testing purposes. Only unlogged areas were included in this analysis because use of logged areas was measured in the initial test. Forest stands were also field-classified into 5 types at each woodpecker observation. The types were lodgepole pine, mixed conifer dominated by lodgepole pine, mixed conifer, mountain hemlock (Tsuga mertensiana), and mountain hemlock-lodgepole pine.

Evaluation of habitat for nesting: A circular plot, with a radius of 82 ft (0.49 acre), was centered on the nest tree to characterize stands used for nesting. The species, condition and dbh of each tree within the circular plot was recorded. Forest stands were characterized by type, management status (unlogged, fuelwood cut, partialcut, shelterwood cut, clearcut), canopy closure, number of layers, presence of bark beetle, and log cover. Ages of stands were confirmed by counting rings in stumps. Nest trees were characterized by species, dbh, height, condition, snag stage, presence of bark beetle (determined from presence of pitch tubes), and top condition (broken or intact). An increment bore was taken near nest cavities on most trees to verify persence of heartrot.

Evaluation of habitat for roosting: A circular plot, with a 41 ft radius (0.12 acre), was centered on the roost tree to characterize stands used for roosting. Characteristics measured were similar to those measured in nest sites.

PART II

SUMMER HABITAT USE BY THREE-TOED WOODPECKERS

INTRODUCTION

The three-toed woodpecker is one of the most inconspicuous Picidae in North America, in part because of its mottled plumage on head and back which blends into the forest shadows, and in part because of its sedentary habits and soft, infrequent vocalizations. Although its distribution is circumboreal, it is typically uncommon. In Oregon, the species is found, except for rare occurrences, only on the east side of the Cascades and in the Siskiyou Mountains. It is typical of the Canadian zone, but may occasionally occur in the Transition zone (Jackman 1974).

Literature on this species is limited. Research on European populations exists but is primarily theoretical. In the United States, there are scattered reports of observations or nests. In Oregon, only 3 nests have been reported (Bull 1980), though others have been found (pers. comm. from R. Hudson, F. Ramsey and E. Styskel). No information on habitat use or distribution by habitat exists. Yet three-toed woodpeckers are an Indicator Species for mature and old-growth lodgepole pine forest types on the National Forests of Area 4 in Oregon (Deschutes, Fremont and Winema).

UPPER STUDY AREA

The upper study area, 4500 to 5400 feet elevation, comprised 13.4 square miles of the High Cascades Province (Figure 2). It included the lodgepole pine and grand fir (Abies grandis) Vegetation Zones (Franklin and Dyrness 1973). Mixed conifer stands of lodgepole pine, Douglas-fir (Pseudotsuga menziesii), grand fir, and ponderosa pine grew in medium textured, productive soils. Pure, or nearly pure, stands of lodgepole pine grew in dry soils, or in frost pocket depressions. Engelmann spruce stands dominated scattered bottomlands and mountain hemlock stands dominated much of the higher elevations. Mixed conifer stands, often dominated by lodgepole pine, comprised 47% of the study area, lodgepole pine stands comprised 21%, mountain hemlock, 2%, and logged areas, 28%.

The current forest landscape has been influenced by timber harvesting since the early 1900's, fire suppression since the 1930's, a mountain pine beetle outbreak in the early 1920's, and a mountain pine beetle epidemic which began in the early 1970's. It appears the previous mountain pine beetle outbreak was confined largely to lodgepole pine and killed some 100 to 300 trees per acre thoroughout the type (USDA Forest Service 1987). Because the beetle prefers large trees, most of the green trees remaining after the outbreak were small to medium diameter trees in the suppressed and intermediate crown classes. These influences have created a well-developed understory of fir, hemlock and spruce, a forest canopy dotted by protruding tops of large remnant trees, and extensive stands of mature and overmature lodgepole pine which are dying from mountain pine beetle attacks. An aggressive harvest program to combat the mountain pine beetle epidemic has created a patchwork of shelterwood harvest units. Seventy-two percent of the study area was unlogged and 28% was logged (Figure 3). Silvicultural prescriptions in shelterwood cuts were generally 30 trees/acre; overstory removal was scheduled when seedlings are established, and typically, woody debris was piled and burned.

RESULTS AND DISCUSSION

Survey Technique: Three-toed woodpeckers responded to play-back recordings of species-specific drumming, usually within 3 minutes. Responsiveness of woodpeckers appeared related to breeding condition, time of day, and distance of resident woodpecker from recording projection. Responsiveness to play-back recordings appeared to coincide with initiation of cavity excavation and responsiveness ceased when egg-laying began. Annual variations in climatic conditions and elevation, which influenced timing of breeding, correspondingly affected timing of responsiveness. The most effective survey period for 5000-5500 ft elevation was between 7 May and 7 June. I estimate a delay in breeding condition of 4-6 days/≈500 ft gain in elevation (modified from Ruge 1974), thus surveys at 4500 ft elevation would be most effective period around the first of May, and surveys at 6000 ft elevation would be most effective around the middle of May. Responsiveness began approximately 1/2 h after sunrise, peaked between 1-2 h after sunrise, and declined up to 5 h after sunrise, after which responses became rare. Responsiveness increased again shortly before sunset, but was not as consistent as in the morning. Variation in responsiveness may have been related to woodpecker detection of the broadcast; woodpeckers may not have heard a recording when at a distant reach of the home range. Recordings could be heard by humans up to 0.5 mi. Frequent playbacks, at about 0.10 mi intervals, yielded more responses than less frequent play-backs. Responsiveness may also relate to availability of trees appropriate for territorial drumming. Motorized transportation was used during searchs, but non-motorized transportation was more effective because of increased opportunity to hear woodpeckers.

Radio transmitter attachment: Five male and 2 female three-toed woodpeckers were tagged with radio transmitters. Home range data were not collected on either female woodpecker because the tail feather with the attached radio was lost prior to radiotelemetry monitoring. During radio-attachment, both female woodpeckers showed signs of stress (panting, feather loss, occasional limpness); both were captured when daily atmospheric temperatures were unusually high (≈100^{o}F), and both weighed aproximately 10 grams less than the mean male weight (X=60 gm, N=4, range=59-61).

Individual home range sizes: Radiotelemetry data to estimate home ranges (minimum convex polygon) were collected on 5 breeding male three-toed woodpeckers. For 2 woodpeckers, only 7 and 27 locations were collected prior to loss of the tail feather with the attached radio; these were excluded from home range analyses because of incomplete data. The areas covered by these woodpeckers during the period they were monitored were 65 and 185 acres. Area-observation curves indicated that 3 woodpeckers had used most of the eventual measured home range when 80 radiotelemetry locations had been recorded (Figure 4).

Sizes of home ranges (minimum convex polygon) for 3 woodpeckers were estimated as 131, 351, and 751 acres from 126, 152, and 170 radiotelemetry locations, respectively (Table 1). These woodpeckers were monitored during 10-20 days over about 1 month. Most locations were after young had fledged or nesting attempts had failed. The estimated size of the area used by each woodpecker increased only slightly between 80 and 140 locations (Figure 4). The estimated home range size increased sharply for the woodpecker with more than 140 locations. Estimated home range sizes appeared to increase with the number of locations, indicating that, at least for the smaller home range estimates, data may be incomplete. Woodpeckers typically used an area of the home range for several days to several weeks, and then changed the area of use, thus whole new areas were used as the duration of monitoring was extended.

Estimated home range sizes were apparently not related to number of young to feed. The woodpecker with the smallest estimated home range produced 2 fledglings and was often seen feeding both. The woodpecker with the largest home range failed in its nesting attempt, and therefore was feeding only itself.

Sizes of home ranges apparently were not related to the amount of unlogged area or the amount of mature and immature forest stands in the home ranges. The unlogged acreage of each home range ranged from 131 to 571 and the acreage in mature/overmature condition ranged from 122 to 264 (Table 2). The proportion of home ranges in unlogged condition ranged from 49 to 100% and the proportion in mature to overmature condition ranged from 29 to 93%.

Habitat selection for home ranges: Habitat selection within home ranges was measured by comparing the proportion of telemetry locations in a habitat type to the proportion of that habitat in each home range. Two woodpeckers selected for mature and overmature stands; both of these woodpeckers selected against logged areas and young stands (Table 3). The home range of the third woodpecker was unlogged and mostly mature and overmature stands, thus selection, by our criteria, could not be measured. Within home ranges, no pattern of selection for forest types was detected (Table 4).

Habitat selection within the study area was measured by comparing the proportion of telemetry locations in a habitat type to the proportion of that habitat on the study area. All 3 woodpeckers selected for single storied mature/overmature sawtimber; all 3 selected against single-storied seedlings, saplings, and poles, and against plantations and cuts (Table 5). Within the study area, no pattern of selection for forest types was detected (Table 6).

Breeding pair home ranges: Although we were unable to radio-tag both adults of a pair of three-toed woodpeckers, field observations suggested the breeding home range of a pair of three-toed woodpeckers was likely larger than the home range of an individual. Woodpeckers were not observed foraging near each other except when near nests. During nesting, we observed that each adult woodpecker typically used a travel corridor to and from the nest area different from the corridor used by the other adult. Reports from Norway have also noted patterns of travel routes which differ between paired breeding three-toed woodpeckers (Wabakken 1973, Hogstad 1976). These reports prompted Sollien et al. (1982) to test the hypothesis and conclude that members of 1 breeding pair of three-toed woodpeckers used separate parts of a breeding home range for foraging.

Intra-and inter specific home range overlap: Intra-specific home range overlap among non-mates was apparently limited or non-existent. During field observations of three-toed woodpeckers, both male and female woodpeckers responded to intruding woodpeckers, or to play-back recordings, with drums, vocalizations, and aggressive displays. Data from 2 adjacent radio-tagged male woodpeckers showed no home range overlap (Figure 5), and these woodpeckers appeared to defend most areas within home ranges.

Inter-specific home range overlap was common. Three-toed woodpeckers were frequently observed foraging, without agressive displays, near black-backed and hairy woodpeckers (Picoides villosus), northern flickers (Colaptes auratus), and Williamson's (Sphyrapicus thyroides), red-breasted (Sphyrapicus ruber), and red-naped (Sphyrapicus nuchalis) sapsuckers. Morphological differences and niche segregation between these species may limit competition for resources (Bull 1980).

Discussion of habitat used for home ranges: Home range models, particularly the minimum convex polygon model, are useful tools for delineating management units, however no home range model can accurately describe the home range of an animal because models interpret lines where often none exist. The disparity in our estimates of home range sizes and the amount of each habitat component, may be related to the model, or to intensity of data collection (i.e. inadequate number of locations to fully describe home ranges) or some component of habitat quality not detected in our analysis. The size of our sample for estimating home ranges, only 3 birds, was extremely small. The absence of any other data, however, forces us to present some guidelines for management purposes. The small sample size, the brief periods of observation, and the apparent correlation between home range sizes and number of locations suggest that the home ranges may be larger than estimated. We therefore recommend a conservative mangement strategy, using the best of data set, rather than a mean.

Utilization-availability analyses showed consistent trends in patterns of habitat use. Mature and overmature stands were selected by the woodpeckers, and logged areas were avoided. We consider the habitat used by the woodpeckers, rather than the habitat avoided, to be the critical component for management purposes. The home range estimate based on the largest data set had 264 acres (35%) in mature and overmature condition. This is the best estimate available of the area required to support an individual three-toed woodpecker.

Separate foraging "home ranges", which overlap at the center, were suggested for members of pairs feeding nestlings. Feeding efficiency of males and females is likely maximized, at least during critical periods, such as breeding or winter, by spatial segregation of habitat. To insure a viable population, sizes of management units need to be based on the requirements of a pair. However, the amount of overlap in home ranges, by members of a pair, is unknown, but appeared to be limited.

The scope of this study limits our ability to recommend silvicultural or logging prescriptions to manage habitat for three-toed woodpeckers. We believe the most effective method currently available to insure habitat for three-toed woodpeckers is to exempt areas (i.e. Woodpecker Management Areas) from commercial or salvage timber management and place those areas under a special management strategy. We recommend Woodpecker Management Areas of 528 acres (from 264 acres per woodpecker) of lodgepole pine or lodgepole pine-dominated mixed conifer forest, maintained in mature or overmature condition, for as long as possible without treatment. The degree of fragmentation within a management unit may influence the potential of the habitat to support a pair of woodpeckers. Fragmentation should be minimized to the extent possible, so that the 528 acres are contiguous, or a series of inter-connected blocks. This approach of designating "set-aside" Minimum Management Requirement or old-growth areas has been used for other Indicator Species, such as pileated woodpeckers and pine martens.

Habitat used for nesting: Twenty nests were located; 16 were on, or near ,the upper study area, and 4 were located outside either study area (Figure 6). Three-toed woodpeckers were not observed on the lower study area. Elevation of nest sites ranged from about 4500-5600 ft. This minimum elevation probably represents the species' elevational tolerance, during summer, for the central Oregon area.

Land form at nest sites was flat or gently sloping. Six nests were located near a source of human disturbance; 3 were adjacent roads with moderate to heavy use for logging and recreation, 1 was adjacent South Century Drive and Mirror Lakes Trailhead Parking lot, 1 was adjacent the Pacific Crest Trail, and 1 was adjacent a lightly used hiking trail. Nesting success (determined by presence of juveniles at or near fledging development) was 53% for 15 nests monitored. Cause of failure was undetermined. Two of 3 (67%) nests in logged areas failed; 5 of 12 (42%) nests in unlogged areas failed. Three of 5 nests failed during incubation and 2 failed during the nestling period; all nests that failed during incubation were in logged areas.

Nine nests were in forest stands field-typed as lodgepole pine, 9 were in mixed conifer dominated by lodgepole pine, 1 was in lodgepole pine-mountain hemlock and 1 was in mountain hemlock. Fifteen (75%) nest stands were undisturbed, 2 had only the largest (>10 in dbh) live trees removed (first cut in shelterwood conversion), 2 were thinned, and 1 was in a shelterwood cut. Mountain pine beetles had infested 16 nest stands.

Habitat selection was tested for the 16 nests on the study area. There was no selection for any of the stand structure classes (Table 7). Lodgepole pine forest type was selected for nesting and mixed conifer was selected against (Table 8).

Mean stem size at nest sites was 8.0 in dbh (S.D.=1.2, range=7-11, n=20) (calculated for each nest site by averaging the dbh of all trees greater than 4.0 in within the 0.49 acre plot). Percent log cover was 17 (S.D.=12.1, range =5-40, n=20). Average log size, estimated as an average for each nest plot, was 6.0 in dbh (S.D.=1.6, range=2-9, n=20). Percent canopy closure at the nest tree was estimated as less than 60% for 19 (95%) nests. These characteristics did not differ between nests in cut and uncut areas. Mean canopy closure for nests in uncut stands was 27% (S.D.=14.9, range=8-61, n=14), and for nests in cut stands was 18% (S.D.=14.4, range=0-35, n=5). The mean basal area per acre for nests in uncut stands was 139 square feet per acre (S.D.=44.7, range=67-238, n=15), and for nests in cut stands, 72 square feet per acre (S.D.=27.8, range=51-113, n=5).

All nests were in lodgepole pine trees. All nest trees appeared to have heartrot; presence of heartrot was verified in 14 trees with an increment bore, and the 6 other trees had external indicators (e.g. dead limb, split top, scar) of potential for heartrot entry, within 2 feet of the nest cavity. Fifteen nest trees were dead and 5 were live. Six nest trees were infested by mountain pine beetle. Of the dead nest trees, 2 were Stage 1 (needles and limbs present), 11 were Stage 2 (needles absent and limbs broken), and 2 were Stage 3 (no limbs). Only 2 nest trees had broken tops. Mean dbh of nest trees was 11 in (S.D.=2.5, range=7-17, n=20). Mean estimated height was 75 ft (S.D.=20.7, range=17-115, n=20).

Mean height of nest cavities was 25 ft (S.D.=10.9, range=8-45, n=20). Entrances of cavities showed no pattern of orientation relative to the 4 cardinal directions. Entrances to 2 three-toed woodpecker cavities measured were 1.5 in wide and 1.75 in long; other cavities appeared similar in size. Cavities occurred under the lean of 6 of 7 leaning nest trees. Other cavities similar in size and shape to the nest cavity were present in 6 of 18 nest trees, but none of the nest trees located in 1986 were occupied in 1987. Three pairs apparently occupied similar areas between years (determined from distinctive plumage patterns); nest trees of each pair were separated by 100-400 yards between years.

Discussion of habitat used for nesting: Three-toed woodpeckers were apparently constrained in this area, during the summer months, by elevation. Elevational constraints in avian species may be related to heat intolerance (Winterbottom 1972). Oregon is the southern edge of the range of three-toed woodpeckers. If the three-toed woodpecker evolved in interior Alaska as speculated (Bock and Bock 1974), the species may be adapted only to cooler climes, which in this area, occur at higher elevations. Therefore, Woodpecker Management Areas for three-toed woodpeckers should be at 4500 ft elevation and higher.

Although samples were small, more nests in logged areas failed than in unlogged areas, and of those that failed, failure during incubation was more common in logged areas, while failure during the nestling period was more common in unlogged areas. Only 1 of 5 nests near a source of human disturbance failed, indicating that some types of human disturbance near nests was not a factor in nest success. The reduced success we observed in logged areas, relative to unlogged areas, may have been related to higher temperatures in cuts where the shading effect of forest canopies was absent. Temperatures in occupied cavities are higher than ambient temperatures (Kendeigh 1961); if three-toed woodpeckers are intolerant of high temperatures, incubating adults may have been forced to abandon eggs. Nesting in logged areas may also increase potential for predation, relative to forested areas, because predators may be more likely to observe nest activity where there is less hiding cover. Nesting success in this study was surprisingly low, given the abundant food created by the mountain pine beetle outbreak. If the species was declining, or at low populations levels, productivity at the level we observed could limit maintenance or build up of populations.

Types of forest stands used by three-toed woodpeckers for nesting appear to vary with geographical location. In northeastern Oregon, three-toed woodpeckers nested in mixed conifer forest stands dominated by lodgepole pine (n=3; Bull 1980). In the eastern United States, a spruce-tamarack (Larix spp.) bog was used, and in Germany, spruce (Picea excelsa) or spruce (Picea abies) and pine (Pinus cembra) forests were used (LaFrance 1983, Ruge 1974, Ruge and Weber 1974). We observed selection for lodgepole pine stands, but all forest types, and logged areas, were used.

Proportionately high use of lodgepole pine stands for nesting may be tied to nest trees; all trees used for nesting were lodgepole pine. Species of trees other than lodgepole were used for nesting in other areas: lodgepole pine in northeastern Oregon, spruce in New York, quaking aspen (Populus tremuloides) in Nova Scotia, and spruce, fir, and pine in Germany (Gibbon 1966, Scherzinger 1971, Ruge 1974, Ruge and Weber 1974, Bull 1980, LaFrance 1983). On the east slope of the Cascades, lodgepole pine trees may be used for nesting more than spruce trees because of variation in natural pruning of the bole. In relatively closed stands of mixed coniferous species boles of lodgepole pine tundergo natural pruning; in contrast, dead lower limbs persist on Engelmann spruce so that access to the bole for exploration and cavity excavation is limited. Bull (1980) related a preference for pines to the smaller proportion of sapwood relative to other tree species.

Lodgepole pine stands may also be used for nesting proportionately more than available because of abundant trees with heartrot. Nest excavation apparently is constrained by presence of heartrot, in this area, as well as others. Of 36 nest cavities measured in Germany, all were excavated in heartrot (Ruge 1974). A three-toed woodpecker nest in Colorado was in a 20 m lodgepole pine that was sound except for a decayed section less than 1 m in length where the nest cavity was located (Miller and Miller 1980). Dependence upon heartrot for nesting may be related to the anatomy of three-toed woodpeckers. Force is a product of mass and acceleration. In species of woodpeckers with only three toes, force of blows comes from body momentum of the posterior body parts, which are massive, relative to the head and neck region (Spring 1965). Loss of the fourth toe allows a delivery stance during blows, which, relative to other species of woodpeckers, extends the body far from the tree prior to blow delivery. A longer distance for blow delivery allows an increase in acceleration of the relatively heavy posterior, thus forceful blows to wood are delivered. During cavity excavation, extension of the body is restricted by the woodpecker's position and by the size of the cavity entrance. The size of entrances to three-toed woodpecker nest cavities barely allows passage of the woodpecker into the nest chamber. It restricts any potential for a woodpecker to extend its body from the substrate prior to blow delivery. Thus, delivery of blows by three-toed woodpeckers during excavation of the vertical chamber of nest cavities is performed by head momentum instead of body momentum. It may be necessary then, for the species to excavate the vertical chamber in wood softened by heartrot.

Other aspects of nesting habitat appear similar throughout the species range. Tree condition was reported for 6 nests in other areas: all trees were dead (Gibbon 1966, Scherzinger 1971, Bull 1980, LaFrance 1983). The mean height of nest cavities in this study, 25 ft, was similar to the mean for 46 nest cavities in Germany, 27 ft (Ruge 1974, Ruge and Weber 1974). The mean dbh of nest trees in this study, 11.0 in, was similar to mean dbhof nest trees elsewhere, 10.0 in in Oregon and 9.5 in in Montana (Bull 1980, McClelland 1977). Although, diameter of trees at cavities was not measured in this study, the smallest dbh recorded for a nest trees was 7.0 in. This nest cavity was at 6 ft height, indicating the diameter at the cavity was similar to the dbh. The smallest reported diameter at cavity height of a nest tree is 4.8 in (Gibbon 1966). Cavities of smaller woodpeckers are occasionally taken over by larger woodpeckers. Selecting nest trees that have a dbh too small for a larger woodpecker to take over and enlarge, may be a means for a small species like the three-toed woodpecker to reduce competition (Bull 1980). We observed a black-backed woodpecker take-over and enlarge an old three-toed nest cavity; the take-over occurred in the 7.0 in dbh tree reported above, indicating that three-toed woodpeckers may need to use trees smaller than 7.0 in dbh to reduce competition from black-backed woodpeckers.

Three-toed woodpeckers were, to some extent, loyal to home ranges between years. This suggests that once a Woodpecker Management Area is occupied, it will continue to be occupied for several years. Presence of several cavities in nest trees suggested repeated use. However, fidelity was variable, perhaps because of disturbance at sites during this study.

Habitat used for foraging: We observed 493 bouts of foraging from the end of April through mid-September, 1986 and 1987. Seventy-nine percent of the observations were of 3 male radio-tagged woodpeckers. Seventy-one percent of the observations were after 1200 h.

Woodpeckers foraged in mixed conifer forest stands during 55% of the observations, in mixed conifer dominated by lodgepole pine during 20%, and lodgepole pine during 14%. Ninety-seven percent of the observations were in unlogged forest stands, although 17% of these had some evidence of fuelwood cutting; 3% were in thinned or partial cut stands.

Selection for foraging habitat was measured using foraging locations from the 3 radio-tagged woodpeckers. Mature and overmature sawtimber was selected for foraging, and stands with seedlings, saplings or poles, multi-storied stands, and cut areas were avoided (Table 9). No selection for forest stand type was apparent (Table 10). Habitat selected for foraging was similar to that for home ranges because most locations used to measure home range selection were during foraging bouts.

Lodgepole pine trees were used for foraging in 63% of the observations and Engelmann spruce in 25%. In 90% of the observations, the trunk of a standing tree was used for foraging, and in 7%, logs were used. Dead trees were used for foraging in 88% of the observations. However, only 31% of the 4 sample trees were dead (point-centered quarter sampling technique = 4 trees > 4 in dbh and closest to the forage tree ine ach cardinal direction. Although this sample was small and may have been biased, it suggested dead trees were used in a greater proportion than available. Of the dead trees, 77% were Stage 1 (i.e. recently dead), and 22% were Stage 2. Mountain pine beetles (determined by presence of pitch tubes) had infested 52% of the trees used for foraging, but were present in 82% of the 4 trees sampled by the point-centered quarter technique. Mean dbh of all trees used for foraging was 15.5 in (S.D.=5.9, range=2-34, n=429). Mean dbh of lodgepole pine trees used for foraging was 11.5 in (S.D.=3.4, range=5-19, n=311). Woodpeckers foraged within the canopy during 52% of the observations, and below the canopy during 47%. Mean foraging height was 30 ft (S.D.=18.9, range=0-90, n=446).

Canopy closure was less than 60% in 58% of the stands, and greater than 60% in 42%. The mean number of stems /acre, for all trees greater than 4 in dbh, was 503. Mean number of stems /acre for mixed conifer stands was 550, for mixed conifer dominated by lodgepole pine, 689, and for lodgepole pine stands, 411. Mean dbh for mixed conifer stands was 11.0 in, for mixed conifer dominated by lodgepole pine, 10.0 in, and for lodgepole pine stands, 9.0 in. Mean basal area (average basal area of tree with average dbh multiplied by average number stems/acre) for mixed conifer stands was 363 ft^2/acre, for mixed conifer dominated by lodgepole pine, 372 ft^2/acre, and for lodgepole pine stands, 182 ft^2/acre.

Prey: Three-toed woodpeckers apparently feed almost exclusively on wood-boring insects, especially larvae and pupae of bark beetles. Stomach contents from three-toed woodpeckers collected in the Soviet Union were 73% bark beetles (n=28 stomachs, Dement'ev 1966). Stomach contents collected in Norway were 66% bark beetles during the breeding season (n=4 stomachs, Collett 1921 in Hogstad 1970), and 90% bark beetles during the non-breeding season (n=5 stomachs, Hogstad 1970). In the United States, concentrations of three-toed woodpeckers apparently in response to outbreaks of bark beetles have been reported (Blackford 1955, Shook and Baldwin 1970, Massey and Wygant 1973, Crockett and Hansley 1978, Bull 1980).

Discussion of habitat used for foraging: Three-toed woodpeckers are sedentary foragers, employing minimal vertical climbing relative to other woodpeckers (Spring 1965). This is a reflection of anatomical design. Woodpeckers with 3 toes instead of 4, climb upward by keeping the breast and abdomen well away from the trunk, and flip the tail outwards with each ascent, to compensate for the tendency to fall backward before the feet regain contact with the climbing surface. This rather awkward movement, and the increased pull of gravity relative to upward progression with the body in close contact with a surface, requires excessive energy expenditure. Thus, three-toed woodpeckers minimize climbing, by foraging in areas with relatively high concentrations of large prey. Mature and overmature trees, because of low vigor, have a high incidence of bark beetles. These trees, selected by woodpeckers in this study, provide an abundant food source, especially when epidemics occur. The data indicate, however, that three-toed woodpeckers did not feed exclusively on mountain pine beetles. Mountain pine beetles attack live pine trees and desert a tree as it is dying. When a tree is completely killed by mountain pine beetles, these primary wood-borers are gone and secondary woodboring insect species attack the tree. Then, as the wood dries, all of these secondary wood-borers depart. Thus, dead trees have few, if any, mountain pine beetles, and trees recently dead contain more secondary wood-borers than trees dead for many years. By foraging primarily on Stage 1 snags (i.e. recently dead snags), three-toed woodpeckers capitalized on an abundant population of secondary wood boring insects. This abundance was related to the mountain pine beetle outbreak, which created extensive habitat for secondary wood-borers.

Three-toed woodpeckers may have selected trees and parts of trees that contained high densities and large sizes of insect prey. Larger species of bark beetles are normally found on the main trunk and the lower half of a tree; smaller species occur higher up (Price 1975, Baldwin 1968). Density of insects also varies, with greatest densities occurring near the ground and decreasing with tree height. It is not surprising then, that three-toed woodpeckers foraged almost exclusively on trunks of trees rather than branches and that they foraged on the lower portions of trees. A comparison of the mean height of foraging woodpeckers, 31.0 ft (9.5 m), to the average height of trees surrounding nest sites, 70.9 ft (21.6 m), suggests that three-toed woodpeckers did indeed forage on the lower portions of trees, where bark beetle density was likely greatest and the largest species of bark beetles occurred.

Our data were similar to that from a study conducted in northeastern Oregon during a mountain pine beetle outbreak (Bull 1980). Mean foraging height was 23 ft and mean height of trees used for foraging was 59 ft, suggesting use of the lower portions of trees. All three-toed woodpeckers observed foraging were on trunks of trees. All trees used for foraging were lodgepole pine; 78% were dead, all Stage 1 snags. The mean foraging height from northeastern Oregon, 23 ft, was extremely close to our mean foraging height for lodgepole pine, 25 ft.

The evaluation of foraging habitat supported information on home range composition; the mature and overmature, unlogged stands selected for home ranges were used for foraging. Provision of adequate foraging habitat may be crucial to maintaining viable populations of three-toed woodpeckers.

<u>Habitat used for roosting</u>: Sixteen roosts, used for 26 nights, by 5 radio-tagged male three-toed woodpeckers, were located. Roosts were located between 29 June and 25 August, 1987, and were typically used for a couple of nights to a couple of weeks. Fourteen roosts were cavities, and 1 was under bark peeling from a tree trunk. At 1 roost area, the bird was not observed; the direction and intensity of

transmitter signals indicated it was on 1 of 3 trees, but no cavity was observed on any of these trees.

Forest stands dominated by Engelmann spruce or mountain hemlock were used for 12 roosts (75%), mixed conifer dominated by lodgepole pine for 2 roosts, and mixed conifer for 2 roosts. Unlogged forest stands were used for 15 roosts (94%), and a stand converted to a partial cut was used for 1. Because the characteristics measured at this site were within the range of those measured at other sites, it was included in all analyses.

Selection for roosting habitat was measured with 18 roosts used by 4 three-toed woodpeckers. Mature and overmature sawtimber was selected for roosts (Table 11). Single-storied stands of seedlings, saplings, and poles, multi-storied stands and cut areas were avoided. Mountain hemlock was only 3% of the study area but was used for 24% of the roosts, indicating strong selection for this forest type; lodgepole pine was avoided for roosting (Table 12).

Canopy closure was less than 60% in 8 of 15 stands, and was greater than 60% in 7 stands. Mean canopy closure was 44% (S.D.=35, range=2-93, n=15). Mean dbh of trees in the roost stand was 9.0 in (S.D.=1.9, range=6-14, n=15). Average number of stems/acre was 437 (S.D.=175.3, range=223-816, n=15). Basal area of roost stands was 193 ft^2/acre (S.D.=83.0, range=61-329, n=15). Mountain pine beetle was present in only 3 forest stands used for roosting. Percent log cover ranged from 5 to 90; 8 of 15 had less than 30% log cover.

Tree species used for roosting varied: 6 were lodgepole pine, 4 were fir spp., 4 were mountain hemlock, 1 was Engelmann spruce, and 1 was undetermined. All 15 roost trees were dead; 11 were Stage 3 or 4 (decayed). Percent bark on roost trees ranged from 0 to 100, with no pattern apparent. Mean dbh of roost trees was 12.0 in (S.D.=2.0, range=9-15, n=15). Mean tree height was 35 ft (S.D.=30, range=12-105, n=15). Thirteen roost trees (87%) had broken tops. Mean roost height was 24 ft (S.D.=10.8, range=10-45, n=15). Although orientation of cavity entrances varied, 7 of 15 (47%) were in the southeast quadrat.

Discussion of habitat used for roosting: Roost stands are likely tied to needs for hiding and thermal cover. Mountain hemlock, the forest type selected for roosts, was dense relative to lodgepole pine types. Also the number of stems per acre was higher and canopy closure was greater in roost stands than nest stands. Dense hemlock and mixed conifer stands may have created a thermally insulated "pocket" by capturing radiant heat from the earth, as ambient temperatures dropped through the night. The snags used for roosting, typically Stage 3 and 4, may have also played a part in providing thermal insulation. Stage 3 and 4 snags are more decayed than Stage 1 and 2. As decay increases, the wood breaks down, and more air space occurs within the snag. Air provides better insulation than wood. Further, the decaying process gives off heat that may contribute to thermal protection for roosting birds. Regardless of the purpose they serve, well decayed snags appeared to be important to three-toed woodpeckers and should be considered in management planning.

PART III

SUMMER HABITAT USE BY BLACK-BACKED WOODPECKERS

INTRODUCTION

The black-backed woodpecker, while relatively elusive, is more conspicuous than the three-toed woodpecker. This is, in part, related to its larger size and weight, more striking plumage (glossy blue-black and on the male, a brilliant yellow crown), its louder and much more frequent vocalizations, and its distribution at lower elevations, where humans are more likely to encounter it. The range of the black-backed, unlike the three-toed, is confined to North America, and while relatively rare, the species can be locally common. In Oregon, black-backed woodpeckers are found only on the east side and near the crest of the Cascades and, rarely, in the Siskiyou Mountains. The species occurs in the Canadian zone, but unlike the three-toed woodpecker, is more common in the Transition zone (Jackman 1974). "The great lodgepole pine forests lying between Bend and Klamath Falls in a more or less unbroken body from the summit of the Cascades to the eastern spurs of the Paulina Mountains is the center of (black-backed) abundance (in Oregon)" (Gabrielson and Jewett 1940: 387).

Literature on this species is virtually nonexistent; its reproductive ecology, and patterns of habitat use have been examined only cursorily in the Blue Mountains (Bull 1980). Yet, its anatomical development closely ties it to wood-boring insects. These insects are most common in mature and overmature forest stands, or other areas of dead and dying trees. This, the species' elevational distribution, and the relative ease with which it can be monitored suggest it is a more appropriate indicator species, than the three-toed woodpecker, for mature and old-growth lodgepole pine in eastern Oregon.

LOWER STUDY AREA

The lower study area, 4350 to 4430 feet elevation, comprised 11.9 square miles (Figure 7) of the High Cascades Province. It was dominated by the lodgepole pine Vegetation Zone (Franklin and Dyrness 1973). Pure, even aged stands of lodgepole pine grew on broad, level areas in coarse textured, dry pumice soils. Where a slight rise in topography occurred, ponderosa pine replaced lodgepole pine. Lodgepole pine stands comprised 51% of the study area, lodgepole pine mixed with ponderosa pine, 7%, ponderosa pine, 1%, and 3% of the area was not described (by TRI-System). Logged areas were 38% of the study area. Water was virtually absent.

The current forest landscape was influenced by fire suppression, occurring since the 1930's. This created a mostly mature and overmature forest, ripe for a bark beetle outbreak. In the early 1970's, a mountain pine beetle epidemic began and peaked in the mid-1980's. The effects of this, and the associated salvage and control logging, dominated the landscape. Fuelwood harvesting had become significant during the 1980's, and was impacting more and more areas.

Fifty-eight percent of the study area was unlogged and 38%, logged (Figure 8). Most management was to control the mountain pine beetle outbreak. Silvicultural treatments were typically shelterwood cuts (30 trees/acre); overstory removal and conversion to plantations had occurred on a few units. Typically, woody debris was piled and burned.

UPPER STUDY AREA

The upper study area, the same as that used for three-toed woodpeckers, comprised 13.4 square miles (Figure 7). Elevation ranged from about 4500 to 5400 feet. This area of the High Cascades Province included the lodgepole pine and grand fir Vegetation Zones (Franklin and Dyrness 1973). Mixed conifer stands of lodgepole pine, Douglas-fir, grand fir, and ponderosa pine grew in medium textured, productive soils. Pure, or nearly pure, stands of lodgepole pine grew in dry soils, or in frost pocket depressions. Engelmann spruce stands dominated scattered bottomlands and mountain hemlock stands dominated much of the higher elevations. Mixed conifer stands, often dominated by lodgepole pine, comprised 47% of the study area, lodgepole pine stands comprised 21%, mountain hemlock, 2%, and logged areas, 28%.

The current forest landscape has been influenced by fire suppression, occurring since the 1930's, timber harvesting, occurring since the early 1900's, and a mountain pine beetle epidemic, which began in the early 1970's. These influences have created a well developed understory of fir, hemlock and spruce, a forest canopy dotted by protruding tops of large remnant trees , and extensive stands of mature and overmature lodgepole pine which are dying from mountain pine beetle attacks. An agressive harvest program to combat the mountain pine beetle epidemic created a patchwork of shelterwood harvest units. Seventy-two percent of the study area was unlogged and 28% was logged (Figure 9). Silvicultural prescriptions in shelterwood cuts were generally 30 trees/acre; overstory removal was scheduled when seedlings were established, and typically, woody debris was piled and burned.

RESULTS AND DISCUSSION

Survey Technique: Black-backed woodpeckers responded to play-back recordings of species-specific drumming, usually within 3 minutes. In general, black-backed woodpeckers were more responsive than three-toed woodpeckers; breeding condition and time of day did not affect black-backed woodpeckers as much as three-toed woodpeckers. Responsiveness to play-back recordings increased as egg-laying approached and declined when incubation began, but continued, throughout the summer, to some extent. Annual variations in climatic conditions and elevation, which influenced timing of breeding, correspondingly affected timing of responsiveness. The most effective survey period for 4300-4400 ft elevation was between 1 May and 1 June. I suspect a delay in breeding condition of 4-6 days/≈500 ft gain in elevation (modified from Ruge 1974), thus surveys at 4300 ft elevation would be most effective around the first of May, and surveys at 5300 ft elevation would be most effective around the middle of May. Responses began approximately 1/2 h after sunrise and peaked between 1-2 h later, but could be elicited throughout the day with varying consistency. Responsiveness increased again shortly before sunset, but was not as consistent as in the morning. Variability in early morning responsiveness may have been related to woodpecker location relative to the broadcast range of the play-back recording; woodpeckers had large home ranges, thus may not have heard a recording when at a distant reach of the home range. Frequent playbacks, at about 0.10 mi intervals, yielded more responses than less frequent play-backs. Responsiveness may also be related to availability of trees appropriate for territorial drumming. Motorized transportation was used during searches, but non-motorized transportation was more effective because of increased opportunity to hear woodpeckers.

<u>Radio transmitter attachment</u>: Radio transmitters were attached to 1 male, 1 female, and both adults of 1 breeding pair of black-backed woodpeckers on the lower study area. On the upper study area, both adults of a 1 breeding pair were tagged with a radio transmitter. Female woodpeckers weighed less than males (1 male=78 g, 1 female=68 g), but responded as well as males to trapping and radio-tagging.

<u>Individual home range sizes</u>: Radiotelemetry data to estimate home ranges were collected on 6 black-backed wooodpeckers. For 3 woodpeckers, only 6, 25 and 31 locations were recorded prior to transmitter failure or loss of tail feather with the radio-transmitter, thus these were excluded from home range analyses. The amounts of area covered by these birds during the brief monitoring period were 61, 80, and 177 acres. Area-observation curves indicated that most of the eventual observed home range had been used by 2 woodpeckers when 80 radiotelemetry locations were recorded, but for 1 woodpecker, the curve increased sharply at about 100 locations (Figure 10).

Sizes of home ranges for 2 male and 1 female black-backed woodpeckers were estimated as 178, 307, and 810 acres (X=557), from 112, 86 and 124 telemetry locations, respectively (Table 13). These estimates were taken over 9-12 days during 3-4 weeks. Most locations were after young had fledged or nesting attempts had failed.

Woodpeckers used many parts of the home range during a typical day, but occasionally moved into previously unused areas, thus the observed home range increased as the duration of monitoring was extended.

Estimated sizes of home ranges appeared inversely related to the proportions of unlogged and mature/overmature stands within the home ranges; the largest home range had the smallest proportion of unlogged and mature/overmature habitat (Table 14). The home range acreage in unlogged and mature/overmature condition varied greatly between woodpeckers from 30 to 146 acres in unlogged condition and 147 to 478 acres in mature to overmature condition.

Habitat selection for home ranges: Habitat selection within home ranges was measured by comparing the proportion of telemetry locations in a habitat type to the proportion of that habitat in the home range. Selection by our definition was not apparent from this analysis, in part because proportions of the home ranges in mature/overmature or unlogged condition were very large. Proportions of locations in the mature/overmature and unlogged stands were, however, higher than the proportionate availability of these types (Table 15). Selection for forest type was not measured because lodgepole pine stands occupied most of the unlogged habitat on the lower study area.

Habitat selection within the study area was measured by comparing the proportion of telemetry locations in a habitat type to the proportion of that habitat on the study area. All 3 woodpeckers selected for single-storied mature/overmature sawtimber; all 3 selected against single-storied seedlings, saplings, poles, and small sawtimber, and against plantations and cuts (Table 16). Selection for forest type was not measured because lodgepole pine stands occupy most of the unlogged habitat on the lower study area.

Breeding pairs home ranges: Home ranges of breeding pairs of black-backed woodpeckers may be larger than home ranges of individuals. The breeding home range for a pair of woodpeckers was not estimated, however, some telemetry locations were recorded for both adults in 2 pairs. For one pair, the home ranges of each adult appeared largely separate with some overlap in the nest area. The other pair was attending 2 fledged juveniles; only 5 locations were recorded for the female and all of these were within the area used by the male.

Intra- and inter-specific home range overlap: Intra-specific home range overlap among non-mates appeared limited or non-existent. During field observations of black-backed woodpeckers without radio-tags, both male and female woodpeckers responded to intruding woodpeckers, or to play-back recordings, with drums, vocalizations, and aggressive displays. Observations of 2 adjacent radio-tagged male woodpeckers showed no home range overlap, although one boundary was partly coterminous (Figure 11). Further, most areas within home ranges were defended by the resident woodpeckers.

Inter-specific home range overlap was observed. Black-backed woodpeckers were frequently observed foraging, without agressive displays, near three-toed and hairy woodpeckers, northern flickers, and Williamson's, redbreasted, and red-naped sapsuckers. Morphological differences and niche segregation between these species may limit competition for resources (Bull 1980).

Discussion of habitat used for home ranges: Home range models, particularly the minimum convex polygon model, are useful tools for delineating management units, however no home range model can accurately describe the home range of an animal because models interpret lines where often none exists. The disparity in our estimates of home range sizes, and the amount of each component, may be related to the model used, or to intensity of data collection (i.e. inadequate number of locations to fully describe home ranges) or some component of habitat quality not measured in our analysis (e.g. habitat fragmentation). The size of our sample for estimating home ranges, only 3 birds, was small. The absence of any other data, however, forces us to present some guidelines for management purposes. The small sample, the brief periods of observation, the area-observation curves, and apparent relationship between home range sizes and number of locations suggest that the home ranges may be larger than estimated. We therefore are recommending a conservative management approach, using the best data set we collected, rather than a mean of all sets.

The habitat used by a species, rather than the habitat avoided, is the critical component for management purposes. Utilization-availablity analyses showed mature to overmature stands were selected by black-backed woodpeckers; logged areas and immature stands areas were avoided. The home range estimate based on the most complete data had 478 acres, or 59%, in mature to overmature stand condition. This is the best estimate of the area required to support a single black-backed woodpecker.

The extent of partitioning of home ranges by pair members may vary seasonally and according to presence of young. The pair that apparently partitioned the home range was observed while adults were attending nestlings; the home range was likely partitioned to improve foraging efficiency while food demands were high. The other pair was observed while attending newly fledged young; the limited flying ability of the newly fledged juveniles may have required both adults of this pair to use the same area. These observations suggest black-backed woodpeckers may use separate areas for foraging when conditions area critical, such as during breeding or winter.

Currently, black-backed woodpeckers have no special status for management purposes (e.g. Indicator Species), yet preservation of the species is required by 36 CFR 219.9. At this time, we believe the best strategy for insuring habitat to support a minimum number of reproductive individuals is to exempt areas (i.e. Woodpecker Management Areas) from commercial or salvage timber management and place those areas under a special strategy, which retains the characteristics of mature and overmature lodgepole pine as long as possible without treatment. We suggest the <u>minimum</u> area used for managing habitat for a pair of black-backed woodpeckers as 956 acres (from 475 acres per woodpecker) of lodgepole pine or lodgepole pine-dominated habitat in mature or overmature condition. The degree of fragmentation within a management unit may influence the potential of the habitat to support a pair of woodpeckers. Fragmentation should be minimized to the extent possible, so that the 950 acres are contiguous or at least inter-connected.
a sale area of 9500 acres could sustain 10 pairs of black-backed woodpeckers, if habitat was suitable. To manage at 60% of the potential, 6 pairs of woodpeckers could be retained if 5700 acres were maintained in a mature or overmature condition. These acreages should be contiguous, or in inter-connected blocks for each potential pair of

woodpeckers. The traditional approach for management of cavity-nesters at 60% of potential by retaining 60% of the snags and live replacement trees may be ineffective for black-backed woodpeckers for two reasons. One - snags provide more than nesting habitat; snag retention at the 60% level is unlikely to occur in sufficient amounts to provide adequate feeding substrate for species dependent on wood-boring insects associated with trees with flaky/scaly bark. Two - this approach addresses a singular, albeit a key, component of the species' habitat. The interrelationships of an old growth, or mature/overmature ecosystem, and the species associated with it, are little known, but likely complex. Land managers do not, at this time, have the information necessary to manipulate habitat and insure these interrelationships will be maintained.

Because inter-specific home range overlap appears common among the cavity-excavating guild, one Woodpecker Management Area can be designated for more than one species, if the habitat needs of each are met (e.g. 1 Area could be for 1 pair of three-toed and 1 pair of black-backed woodpeckers, if elevation and habitat is suitable for both).

<u>Habitat used for nesting</u>: Characteristics of habitat were measured at 35 black-backed woodpecker nests in the Deschutes National Forest; 13 were located on the upper study area (Figure 12), 9 on the lower study area (Figure 13), and 13 were not on either study area. Land form at all nest sites was flat or gently sloping. Elevation ranged from 4350 - 5400 ft. Eleven of 35 (31%) nests were near a source of human disturbance; 9 were adjacent roads with moderate to heavy use for logging and recreation, 1 was adjacent South Century Drive, and 1 was adjacent a well used hiking and horse trail. The success rate of 19 nests monitored was 63%. Causes of failure were not determined, but 5 failed during incubation, 1 during the nestling period, and timing was not determined for 2 nests. The success rate for 6 nests in logged areas was 83%, and for 13 nests in unlogged areas, 54%.

Thirty-one nests (89%) were in lodgepole pine stands, and 4 were in mixed conifer stands dominated by lodgepole pine. Seventeen (49%) nest stands were undisturbed, 9 (26%) were in stands cut for fuelwood, and 9 (26%) were in logged areas. Of these 9 in logged areas, 5 were in partial cuts, 1 was in a stand being converted to a shelterwood cut, where only the largest (>10 in dbh) live trees had been removed, 1 was in a shelterwood cut, and 2 were adjacent shelterwood cuts.

Eight nests on the lower study area were used to measure selection by black-backed woodpeckers for nesting habitat. Mature and overmature stands of sawtimber were selected (Table 17). Selection for forest types was not tested because lodgepole pine stands dominate the lower study area. Twelve nests were used to measure selection for nesting habitat on the upper study area. Multi-storied stands were selected and single-storied stands avoided; cut areas were used opportunistically (Table 18). No selection for any of the forest types or logged areas was detected on the upper study area (Table 19).

Mountain pine beetle had infested 23 (66%) of the nest stands. Mean stem size at nest sites was 8.0 in dbh (S.D.=1.5, range=5-11, n=32), calculated for each nest site by averaging the dbh of all trees greater than 4 in within the 0.49 acre plot. Percent log cover was 13 (S.D.=10.7, range=2-50, n=34). Mean log size, estimated as an average for each nest plot, was 7 in dbh (S.D.=1.8, range=3-14, n=32). Mean basal area for nests in lodgepole pine was 79 ft^2/acre (S.D.=43.9, range =17-167, n=29), and for nests in mixed conifer dominated by lodgepole pine, 136 ft^2/acre (S.D.=51.7, range=95-204, n=4). Mean basal area for uncut stands was 112 ft^2/acre (S.D.=45.2, range=46-204, n=16), for nests in fuel cut stands, 79 ft^2/acre (S.D.=26.3, range=31-121, n=9), and for nests in partial cut or shelterwood stands, 34 ft^2/acre (S.D.=23.6, range=17-77, n=6). Mean canopy closure for nests in uncut stands was 24% (S.D.=14.7, range=3-61, n=25), and for nests in cut stands was 11% (S.D.=8.3, range=3-25, n=6). Mean stem size for uncut stands surrounding nest trees was 8 in dbh (S.D.=1.1, range=6-10, n=17) and for fuel, partial and shelterwood cut stands, 7 in dbh (S.D.=1.8, range=5-10, n=15).

All nests were in lodgepole pine trees. All nest trees appeared to have heartrot; presence of heartrot was verified in 17 trees with an increment bore, and in 9 other trees, external indicators (e.g. dead limb, split top, scar) of potential for heartrot entry occurred within 2 feet of the nest cavity. Twenty-two (65%) nest trees were live and 12 were dead. Of the dead nest trees, 7 were Stage 1 (recently dead) and 5 were Stage 2. Twelve (35%) nest trees were infested by mountain pine beetle. All nest trees had intact tops. Mean dbh of nest trees was 11.0 in (S.D.=2.0, range=7-19, n=33). Mean estimated height was 70 ft (S.D.=15.9, range=40-120, n=33).

Bark was removed from the tree trunk at the cavity entrance, thereby exposing the sapwood, at 23 (66%) nests. Mean nest cavity height was 12 ft (S.D.=9.7, range=8-54, n=35). Entrances of cavities showed no pattern of orientation relative to the 4 cardinal directions. Cavities occurred under the lean of 6 of 7 leaning nest trees. Cavities, similar in size and shape to nest cavities, were present in 6 of 18 nest trees.

Discussion of habitat used for nesting: Use of nest stands by black-backed woodpeckers appeared. Reports from other areas, although limited, support this. Bull (1980) located 9 black-backed woodpecker nests in northeastern Oregon and found no selection for any characteristics on the study area except that nest trees were smaller, and more recently dead than expected from availability. Nests were in lodgepole and ponderosa pine trees. Nest stands were mostly ponderosa pine type. Mean canopy closure of nest stands was 46%. Mean basal area was 86 ft^2/acre. McClelland (1977) located 2 black-backed nests in the northern Rocky Mountains: one in a Douglas fir snag in a recently burned area and one in a live western larch (Larix occidentalis) in a recent shelterwood cut. In Michigan, one nest was reported in a dead jack pine (Pinus banksiana) tree in a burned jack pine area (Mayfield 1958). In Minnesota, 2 reports were cited: 1 nest in a burned and cut area, and 1 in a cut area (Gresser, J. and K. 1974). Another report from Minnesota describes a nest in a solitary water-killed red pine (Pinus resinosa) in a transition pond-bog (Cottrille 1974). In British Columbia, 1 nest in a Douglas-fir was reported (Erskine 1959). Black-backed woodpeckers apparently have a broad tolerance level for canopy closure and stem density, and apparently can nest in cut, burned and open areas as successfully as undisturbed areas.

Nest success in this study appeared better in logged areas than unlogged areas. Two possible explanations for this disparity in rates are: (1) logged areas are better for nesting than unlogged areas, and (2) predation rates are higher in unlogged than logged areas because logged areas are unsuitable habitat for predators (e.g. flying squirrels (Glaucomys sabrinus), chickarees (Tamiasciurus douglasi). The former explanation seems unlikely since the evolution of black-backed woodpeckers occurred in the absence of logging. However, the species did evolve when fires were a common phenomenon. Woodpeckers may have nested in burned over areas because of hgh prey abundance. Although there are structural similarities between burned areas and shelterwood cuts, the difference in the prey base for woodpeckers is dramatic; shelterwoods would rarely be capable of providing a source of nearby, abundant food for breeding woodpeckers. We suspect the higher nest success in logged units was related to reduced predation; in unlogged areas, predated eggs were observed at one nest, predation of nestlings was suspected at another, and at 2 nests, we interrupted apparent predation attempts by chickarees. For many predators, such as chickarees, which primarily use unlogged areas, competition for food may be intensifying as more individuals are crowded into the remaining unlogged areas. Thus, predation pressure on cavity nesters in unlogged stands may be increasing.

Presence of heartrot apparently was an important factor in nest site selection for black-backed woodpeckers in our study. Dependence upon heartrot for nesting may be related to the anatomy of black-backed woodpeckers. Force is a product of mass and acceleration. In species of woodpeckers with only three toes, force of blows comes from body momentum of the posterior body parts, which are massive, relative to the head and neck region (Spring 1965). Loss of the fourth toe allows a delivery stance during blows, which, relative to other species of woodpeckers, extends the body far from the tree prior to blow delivery. A longer distance for blow delivery allows an increase in acceleration of the relatively heavy posterior, thus forceful blows to wood are delivered. During cavity excavation, extension of the body is restricted by the woodpecker's position and by the size of the cavity entrance. The size of entrances to black-backed woodpecker nest cavities barely allows passage of the woodpecker into the nest chamber. It restricts any potential for a woodpecker to extend its body from the substrate prior to blow delivery. Thus, delivery of blows by black-backed woodpeckers during excavation of the vertical chamber of nest cavities is performed by head momentum instead of body momentum. Because force of blows is limited, it may be necessary then, for the species to excavate the vertical chamber in wood softened by heartrot.

Diameter at breast height of nest trees used by black-backed woodpeckers may be influenced by competition and frequency of take-over by other larger woodpeckers. Cavities of smaller woodpeckers are occasionally taken over by other woodpeckers. We observed a hairy woodpecker nesting in a cavity newly excavated by a black-backed woodpecker. Bull (1980) suspected black-backed woodpeckers may be particularly vulnerable to take-over of cavities by other woodpeckers; this species is the only woodpecker she observed to lose a new cavity to another woodpecker. Black-backed woodpeckers may limit competition for their nest cavities by using nest trees that are too small in diameter for larger woodpeckers to usurp.

The habit of peeling bark from entrances to nest cavities is common in black-backed woodpeckers. Benefits of this habit are unknown. Cavities which have the bark peeled from the entrance are more obvious, at least to the human eye, than cavities which do not have the bark peeled; it has been suggested that this aids woodpeckers in locating their nests. Red-cockaded (Picoides borealis) woodpeckers have a similar habit (Hooper et al. 1980); it has been speculated that the resin flows created by bark removal are poisonous to rat snakes, a common predator in the habitat occupied by red-cockaded woodpeckers. Resin flows created by black-backed woodpeckers may serve as a deterrent to some predators.

Habitat used for foraging: Foraging by black-backed woodpeckers was observed during 395 bouts, ocurring from the end of April through end of August, 1986 and 1987. Seventy-one percent of the observations were of 2 male and 1 female radio-tagged woodpeckers. Eighty-two percent of the observations were on the lower study area and 76% were after 1200 h.

Woodpeckers foraged in lodgepole pine forest stands during 93% of the observations, however most observations were from the lower study area, which was comprised primarily of the lodgepole pine forest type. Mixed conifer was used during 5% of the observations, and mixed conifer dominated by lodgepole pine, during 2%. Uncut forest stands were used during 88% of the observations, and stands cut for fuelwood during 12%; use of logged stands was not observed. All 3 radio-tagged woodpeckers selected for mature and overmature sawtimber, and against young stands, multi-storied stands and cut areas (Table 20). Habitat selected for foraging was similar to that selected for home ranges because most locations used to calculate home ranges were during foraging bouts. Selection for forest types was not tested because most of the foraging observations were from the lower study area, which was comprised primarily of the lodgepole pine type.

Canopy closure was less than 60% in 74% of the stands, and greater than 60% in 26%. The mean number of stems per acre, for all trees greater than 4.0 in dbh, was 503. Mean stems per acre for mixed conifer stands was 550, for mixed conifer dominated by lodgepole pine, 689, and for lodgepole pine stands, 411. Mean dbh for mixed conifer stands was 11.0 in, for mixed conifer dominated by lodgepole pine, 10.0 in, and for lodgepole pine stands, 9.0 in. Mean basal area (average basal area of tree with average dbh multiplied by average number stems/acre) for mixed conifer stands was 363 ft^2/acre, for mixed conifer dominated by lodgepole pine, 413 ft^2/acre , and for lodgepole pine stands, 411 ft^2/acre.

Woodpeckers foraged on lodgepole pine trees in 97% of the observations. In 96% of the observations, the trunk of a standing tree was used for foraging, and in 4%, logs were used. Dead trees were used during 68% of the observations. However, only 28% of the sample trees were dead (point-centered quarter sampling technique = 4 trees > 4 in dbh and closest to the forage tree in each cardinal direction). Although this sample was small and may have been biased by proximity, it suggested dead trees were used in a greater proportion than available. Mountain pine beetles (determined by presence of pitch tubes) had infested 81% of the trees used for foraging, but were present in only 36% of the 4 sample trees. Ninety-four percent of the dead trees were Stage 1 snags (recently dead), and 6% were Stage 2. Mean dbh of all trees used for foraging was 15.0 in (S.D.=4.9, range=2-39, n=340). Mean dbh of lodgepole pine trees used for foraging was 14.0 in (S.D.=4.7, range=2- 39, n=330). Woodpeckers foraged within the canopy during 52% of the observations, and below the canopy during 49%. Mean foraging height was 17 ft (S.D.=11.2, range=0-60, n=339).

<u>Prey</u>: Detailed information about prey of black-backed woodpeckers is not available. However, stomachs containing only wood-boring larvae were reported by Beal (1911), Grinnel et al. (1930), Bent (1939), and Wickman (1965). Bull (1980) reported that black-backed woodpeckers preferred lodgepole pine trees for foraging,

presumably because of a mountain pine beetle outbreak infesting much of the lodgepole. Black-backed woodpeckers appear, from other reports, to have a narrow feeding niche, and to be closely tied to abundances of wood boring insects.

Discussion of habitat used for foraging: Our data suggested black-backed woodpeckers fed almost exclusively on larvae of mountain pine beetles during the period of observation. Black-backed woodpeckers selected lodgepole pine trees that were live or Stage 1 snags for 94% of the foraging observations. Stage 1 snags are generally trees that were attacked by mountain pine beetles and killed the previous summer, but still contain the larvae which had not yet emerged as adults, during the time of most of our observations (prior to mid-July),. This suggests that black-backed woodpeckers were relying primarily on mountain pine beetles as a food source. Increases in numbers of black-backed woodpeckers have been noted during outbreaks of mountain pine beetle in pine forests of Montana, Colorado, and Oregon (Blackford 1955, Crockett and Hansley 1978, Bull 1980). Yunick (1985) suggested that the black-backed woodpecker tends to be an irruptive species. Population fluctuations locally, with abundances of wood boring insects are probably common for this species. The population of black-backed woodpeckers on the east slope of the Cascade Mountain Range likely has increased, with the increase in food abundance created by the mountain pine beetle outbreak. During bark beetle outbreaks, tree-killing, while extensive, is rather patchy and variable in intensity; scattered mature and overmature trees and stands survive. Between outbreaks, the bark beetle population stays at low levels but susceptible trees scattered throughout the forest are attacked and killed, scattered localized outbreaks develop now and then, trees surviving the previous outbreak undergo natural mortality, fires spread and storms create windthrown trees; all of these provide a continuum of prey and habitat for black-backed woodpeckers during periods between outbreaks. Fire suppression and the current pest management program on the National Forests of Area 4 is interrupting this pattern and removing virtually all of the habitat for maintaining populations of black-backed woodpeckers during the "troughs" of the bark beetle-lodgepole pine "cycle".

Black-backed woodpeckers may have foraged in trees and parts of trees that contained high densities and large sizes of insect prey. Larger species of bark beetles are normally found on the main trunk and the lower half of a tree; smaller species occur higher up (Baldwin 1968, Price 1975). Density of insects also varies, with greatest densities occurring near the ground. It is not surprising then, that black-backed woodpeckers foraged almost exclusively on trunks of trees rather than branches. The mean height of foraging woodpeckers, 17 ft, suggests that black-backed woodpeckers did indeed forage on the lower portions of trees, where bark beetle density was likely greatest and the largest species of bark beetles likely occurred. Black-backed woodpeckers, like three-toed woodpeckers, are sedentary foragers which exhibit minimal verticle climbing. Woodpeckers with 3 toes instead of 4, climb upward by keeping the breast and abdomen well away from the trunk, and flipping the tail outwards with each ascent to compensate for the tendency to fall backward before the feet regain contact with the climbing surface. This rather awkward movement, and the increased pull of gravity relative to upward progression with the body in close contact with a surface, requires excessive energy expenditure. It is not surprising then, that black-backed woodpeckers forage in areas with relatively high concentrations of large prey, thereby minimizing energy expended by climbing.

Our data was similar to a study conducted in northeastern Oregon during a mountain pine beetle outbreak (Bull 1980). Lodgepole pine trees were preferred for foraging. Mean dbh of forage trees was 12.0 in. About half (53%) of the trees used for foraging were live; most were apparently infested with mountain pine beetles. The mean foraging height from northeastern Oregon, 32 ft, varied by about 50% from our mean foraging height of 17 ft.

The evaluation of foraging habitat supported information on home range composition; the mature and overmature, unlogged stands selected for home ranges were used for foraging. Provision of adequate foraging habitat may be crucial to maintaining viable populations of black-backed woodpeckers.

Habitat used for roosting: Twenty roost sites, used for a total of 24 nights by 4 radio-tagged black-backed woodpeckers, were located. Roosts were located between between 16 June and 20 July, 1987. None of the roosts were cavities; 4 roosts were in concave western gall rust cankers, 2 roosts were in deep trunk scars, 2 roosts were on the trunk, 1 was where a branch forked, creating an indentation in trunk, 1 was in a mistletoe clump, and 10 were not determined.

All roosts on the lower study area were in lodgepole pine forest stands. Of the 5 roosts on the upper study area, 2 were in stands of lodgepole pine-mountain hemlock, 1 was in mixed conifer dominated by lodgepole pine, 1 was in mixed conifer, and 1 was in lodgepole pine. Unlogged forest stands were used for all roosts.

Thirteen roosts on the lower study area were measured for habitat selection. Mature and overmature sawtimber was selected for roosts (Table 21). Single-storied stands of seedlings, saplings, and poles, multi-storied stands and cut areas were avoided for roosting. Selection for forest type was not tested since most of the lower study area was lodgepole pine. Only 5 roosts, all from one bird, were located on the upper study area; this sample size prevented testing for selection on the upper study area.

Canopy closure, in 14 of 18 (78%) stands measured, was less than 60%, and in 4 stands, was greater than 60%. Mean canopy closure was 40% (S.D.=24.6, range=4-98, n=18). Mean dbh of trees in the roost stand was 6 in (S.D.=1.3, range=4-9, n=18). Basal area of roost stands was estimated as 115 ft^2/acre (S.D.=46.2, range=56-261, n=18). Mountain pine beetle was present in 7, and absent from 11 forest stands used for roosting.

Lodgepole pine trees were used for 14 roosts, fir spp. for 1 roost, and the exact tree was not determined for 3. Live trees were used for 13 (87%) roosts, and dead trees for 2. Mean dbh of roost trees was 11.0 in (S.D.=4.5, range=4-20, n=15). Mean tree height was 65 ft (S.D.=24.5, range=40-125, n=13). Mean roost height was 21 ft (S.D.=8.2, range=11-33, n=8). No pattern of roost orientation, relative to the 4 cardinal directions, was detected.

<u>Discussion of habitat used for roosting</u>: Black-backed woodpeckers, unlike three-toed woodpeckers, did not roost in cavities during the summer. Nonetheless, roosts used by black-backed woodpeckers likely provided thermal protection and hiding cover from predators. Roosts in concave areas on trunks and in mistletoe clumps, likely provide some, albeit limited, thermal protection. When roosting, woodpeckers drew their bodies close to the trunk. This, and the concave pocket, may

have served to conserve heat. Predator avoidance may have been a more important factor than thermal protection. When woodpeckers were flattened against the trunk of trees, no silhouette was visible. In fact, woodpeckers were often not visible to us, even when we knew, from the strength and direction of transmitter signals, which tree was occupied.

Stands used for roosting may also have aided in thermal protection. Roost stands had relatively small trees, high stem density, and relatively closed canopies. This stand structure may serve as a heat sink relative to a more open stand. A more important role provided by these stands may have been inhibiting predators. Nocturnal avian predators (e.g. great horned owls (Bubo virginianus)) are generally constrained by flight agility, and could not readily maneuver through these dense stands.

Diseased or deformed trees appear to be important to black-backed woodpeckers for roosts. In managing habitat for this species, this component of their habitat should be provided.

PART IV
MANAGEMENT IMPLICATIONS

Three-toed and black-backed woodpeckers were studied during spring and summer of 1986 and 1987 in areas infested by epidemic levels of mountain pine beetle. A small number of birds of each species were radio-tagged. Because of the brief time period, unusual circumstances (i.e. beetle epidemic), and small sample size of radio-tagged birds, conclusions drawn from the data are conservative and represent the best information available, rather than complete information on management of these species. Recommendations for management of these species may change as more data on patterns of habitat use are collected.

Management for three-toed and black-backed woodpeckers is tied to maintenance of disease and decay: trees with heartrot for nests, diseased trees or decayed snags for roosts, and adequate decaying substrate to provide a sufficient prey base of wood-boring insects. These conditions are detrimental to maximizing timber outputs. We believe the most effective method currently available to insure habitat for three-toed and black-backed woodpeckers is to exempt areas (i.e. Woodpecker Management Areas) from commercial or salvage timber management and place those areas under a special management strategy, which retains the characteristics of mature or overmature lodgepole pine habitat as long as possible, without treatment. Designate Woodpecker Management Areas in lodgepole pine or lodgepole pine-dominated stands with the greatest probability of surviving the longest time, but if these stands no longer retain the characteristics of mature/overmature stands, or if the number of trees remaining is inadequate to support a pair of woodpeckers, relocate the designated Woodpecker Management Area to selected replacement areas. Replacement stands should be selected now, to provide the earliest possible replacement for declining Woodpecker Management Areas. Woodpecker Management Areas, and replacement areas, may be within areas previously designated as protected, such as old growth areas, Spotted Owl Habitat Areas, winter recreation sites, Research Natural Areas, etc.

Management Areas for each pair of three-toed woodpeckers should be 528 acres of mixed conifer or lodgepole pine forest in mature and overmature condition and at an elevation of 4500 ft or higher. Management Areas for each pair of black-backed woodpeckers should be 956 acres of lodgepole pine or lodgepole pine-dominated mixed conifer forest in mature and overmature condition. One Management Area of 956 acres, at a minimum elevation of 4500 ft, could be designated for 1 pair of both species. However, Management Areas for black-backed woodpeckers should not be restricted to elevations greater than 4500 ft because this species may be better adapted to conditions at lower elevations than at higher elevations.

Black-backed woodpeckers are not currently assigned a special status (e.g. Indicator Species), thus designation of Woodpecker Management Areas may not be practical for the species. An alternative management strategy can be applied on a sale-by-sale basis. On each sale, habitat can be preserved for each pair of black-backed woodpeckers by removing 956 acres of inter-connected blocks of mature/overmature habitat from harvest. For example, if a sale area is 9500 acres of mature or overmature lodgepole pine-dominated habitat, management at 60% of potential would be for 6 pairs, or 6 areas of 950 acres each. The traditional approach for management of cavity-nesters at 60% of potential by retaining 60% of the snags and live replacement tree may be ineffective for black-backed (or three-toed) woodpeckers for two reasons. One - snags provide more than nesting habitat; snag retention at the 60% level is unlikely to occur in sufficient amounts to provide adequate feeding substrate for species dependent on wood-boring insects associated with trees with flaky/scaly bark. Two - this approach addresses a singular, albeit a key, component of the species' habitat. The interrelationships of an old growth, or mature/overmature ecosystem, and the species associated with it, are little known, but likely complex. Land managers do not, at this time, have the information necessary to manipulate habitat and insure these interrelationships will be maintained.

The figures for home range sizes and the amount of mature or overmature stands used by woodpeckers were estimated under conditions of abundant food supply. As the mountain pine beetle epidemic runs its course, and prey abundance declines, it is likely that the amount of area required to support a pair of three-toed or black-backed woodpecker will increase.

The characteristic stand structure associated with mature and overmature lodgepole pine may disappear on Woodpecker Management Areas, and throughout the lodgepole pine forests of the Oregon Cascades, because these stands are the prime target of the mountain pine beetle. Areas which experience high mortality nonetheless provide habitat for three-toed and black-backed woodpeckers. Dead and down material provides hiding cover, but more importantly, provides forage substrate. Treatment severely reduces forage substrate because dead trees and trees with low vigor, which are susceptible to attack by wood-boring insects, are removed. Without treatment, the magnitude of the problem is reduced; stands may survive or trees remain standing 10, 15 or 20 years, and mortality may be patchy, thus the remaining vigorous trees provide a continuum of habitat. With treatment, stands are immediately converted to a vigorous condition where incidence of death and decay is severely restricted, thus the potential to provide forage substrate is drastically reduced. Although in time, the results of treatment may be similar to that of no treatment, the time to reach that status differs significantly. By avoiding treatment, stands continue to provide habitat over a longer time, thus the period when old growth lodgepole pine is absent or scarce, is shorter, and a larger population of woodpeckers survives.

Conversion to and maintenance of lodgepole pine stands in a young, vigorous condition may eliminate or severely restrict incidence of heartrot. Three-toed and black-backed woodpeckers, because of morphological adaptations associated with three-toes on each foot, require heartrot for cavity excavation. Absence of heartrot, or reduced incidence, may lead to declines in populations of these species.

Data indicate the three-toed woodpecker may be an appropriate Indicator Species for mature and old growth lodgepole pine, but only at elevations greater than 4500 ft. Much of the pure lodgepole pine, on the east slope of the Cascade Mountain Range in Oregon, occurs at elevations less than 4500 ft. We recommend the black-backed woodpecker as an Indicator Species for mature and old growth lodgepole pine, instead of the three-toed woodpecker. Unlike the three-toed woodpecker, the black-backed woodpecker uses a range of elevations that is synchronous with that of lodgepole pine. Futher, it responds to play-back recordings more frequently, over a longer time period, and with louder vocalizations than the three-toed woodpecker, thus may be more effectively monitored than the three-toed woodpecker.

Three-toed and black-backed woodpeckers should be monitored to track changes in population levels. Survey routes to document number of woodpecker responses should be monitored annually during May. Population levels of three-toed and black-backed woodpeckers prior to the mountain pine beetle epidemic, were undocumented, thus the effects of the mountain pine beetle epidemic on population levels is unknown. Yunick (1985) reviewed information on irruptions by three-toed and black-backed woodpeckers in eastern North America and suggested that populations of black-backed woodpeckers increase with increasing prey abundance, but that populations of three-toed woodpeckers are much less responsive to changes in prey abundance. It is possible that numbers of black-backed woodpeckers increased as the density of mountain pine beetles increased on the Deschutes National Forest. Similarly, populations may decline as the epidemic runs its course and prey for the woodpeckers becomes scarcer. It may be difficult to distinquish between the effects, on black-backed and three-toed woodpeckers, of the epidemic and of timber management to control the epidemic. Documenting breeding success in Management Areas may be an effective method of combatting public outcry if woodpecker populations decline on the Forest.

This study provides a preliminary data base on habitat use by three-toed and black-backed woodpeckers; it is intended as a springboard for other studies. The pioneering nature of the study required a limited time frame, geographic scope, and sample size. Consequently, management recommendations represent the best available information at this point in time, but are intended to evolve as more information becomes available. Additional research should be a priority for land managers. Research needs include: (1) information on habitat use in areas without a bark beetle epidemic, (2) estimates for home range sizes of individuals of both species under current and other conditions, (3) estimates for breeding home range sizes of both species, (4) information on flexibility of the species to adjust to managed forest habitat, (5) information on the relationship of habitat quality and fragmentation to home range size, and (6) information on juvenile dispersal.

LITERATURE CITED

Baldwin, P. H. 1968. Woodpecker feeding on Engelmann spruce beetle in windthrown trees. Research Note, Rocky Mountain Range and Forest Experiment Station, USFS No. 105, 4 pp.

Beal, F.E.L. 1911. Food of the woodpeckers of the United States. U.S. Dept. Agr. Biol. Surv. Bull. 37. 64pp.

Bent, A. C. 1939. Life Histories of North American Woodpeckers. 334 pp. Dover Publications, New York.

Blackford, J. L. 1955. Woodpecker concentration in burned forests. Condor 57:28-30.

Bock, C. E. and J. H. Bock. 1974. On the geographical ecology and evolution of the three-toed woodpeckers. American Midland Naturalist 92:397-405.

Bull, E.L. 1980. Resource partitioning among woodpeckers in northeastern Oregon. Ph. D. thesis. University of Idaho. 109 pp.

---1986. Ecological value of dead trees to cavity-nesting birds in northeastern Oregon. Oregon Birds 12 (2):91-99.

Collett, R. 1921. Norges Fugle II. O. Olsen, Ed. Aschehoug, Kristianaia. 610 pp.

Cottrille, B.D. 1974. Some additional observations on the nesting of the black-backed three-toed woodpecker in Michigan. Jack-Pine Warbler 52 (3):148-150.

Crockett, A. B. and P. L. Hansley. 1978. Apparent response of Picoides woodpeckers to outbreaks of the pine bark beetle. Western Birds 9:67-70.

Dement'ev, G. P. 1966. Northern three-toed woodpeckers, pp. 624-627 in Dement'ev, G. P. and Gladkov, N. A. (eds.) Birds of Soviet Union, Volume 1. (In Russian).

Erskine, A.J. 1959. Picoides arcticus nesting in the Cariboo, British Columbia. Canadian Field-Naturalist 73:205.

Franklin, J. F and C. T. Dyrness. 1969. Vegetation of Oregon and Washington. USDA Forest Service Research Paper PNW-80. 216 pp. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Gabrielson, I. N. and S. G. Jewett. 1940. Birds of Oregon. Oregon State University, Corvallis, Oregon. 650 pp.

Gibbon, R. S. 1966. Observations on behavior of northern three-toed woodpeckers in central New Brunswick. Canadian Field Naturalist 80:223-226.

Gresser, Jerome and Karol. 1974. Nesting black-backed woodpecker. The Loon:176.

Grinnell, J., J.S. Dixon, And J. M. Linsdale. 1930. Vertebrate natural history of a section of northern California through the Lassen Peak region. Univ. Calif. Pub. Zool. 35. 594pp.

Hooper, R.G., A.F. Robinson,Jr., and J.A. Jackson. 1980. The red-cockaded woodpecker: notes on life history and management. U.S. Dept. Agric. For. Serv. Gen. Rep. SA-GR9. 8pp.

Hogstad, O. 1970. On the ecology of the three-toed woodpecker outside the breeding season. Nytt magasin for Zoologi 18 (2):221-227.

---1976. Interrseksuell deling av forplantningsterritoriet hos tretaspett. Sterna 15:5-10. (In Norwegian).

Jackman, S. M. 1974. Woodpeckers of the pacific northwest: their characteristics and their role in the forests. M. S. thesis. Oregon State University. 147 pp.

Johnson, D.H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61 (1):65-71.

Kendeigh, S.C. 1961. Energy of birds conserved by roosting in cavities. Wilson Bulletin 73 (2):140-147.

LaFrance, F. 1983. Adirondack woodpeckers in unusual plumages. Kingbird 33(2):165-166.

Mayfield, H. 1958. Nesting of the black-backed three-toed in Michigan. Wilson Bulletin 70 (2):195-196.

McClelland, B. R. 1977. Relationships between hole-nesting birds, forest snags, and decay in western larch-Douglas fir forests of the northern Rocky Mountains. Ph. D. thesis. University of Montana, Missoula. 496 pp.

Mellen, T.K. 1987. Home range and habitat use by pileated woodpeckers. M.S. Thesis. Oregon State University, Corvallis. 96pp.

Miller, E. and D. R. Miller. 1980. Snag Use by Birds in Workshop Proceedings: Management of Western Forests and Grasslands for Nongame Birds, U. S. D. A. Forest Service General Technical Report INT-86, 535 pp. Intermountain Forest and Range Experiment Station, Ogden, Utah, 84401.

Mohr, C.O. 1947. Table of equivalent populations of North American small mammals. Am. Midl. Nat 37:223-249.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. 547pp. Wiley and Sons, Inc. New York.

Price, P. W. 1975. Insect Ecology. Wiley and Sons, New York.

Ruge, Klaus. 1974. On the biology of the three-toed woodpecker/Breeding biology and breeding ecology data for Switzerland. Ornithologische Beobachter 71(5/6):303-311. (In German with English summary).

—and W. Weber. 1974. Breeding territories of the three-toed woodpecker in the Eisenerz Area, Steiermark, Austria. Anzeiger der Ornithologischen Fesellschaft in Bayern 13(3):300-304. (In German).

Scherzinger, W. 1971. Observations on the three-toed woodpecker. Gefiederte Welt 95(9):163-165

Sollien, A., B. Nesholen, and J. E. Fosseidengen. 1982. Horizontal partition of the breeding territory of the three-toed woodpecker. Cinclus 5:93-94.

Spring, L. W. 1965. Climbing and pecking adaptations in some North American woodpeckers. Condor 67:457-488.

USDA Forest Service, Deschutes National Forest. 1987. Environmental Assessment for bark beetle infestation in ponderosa pine (Pinus ponderosae) and lodgepole pine (Pinus contorta).

Wabakken, P. 1973. Observations at nest of grey-headed and three-toed woodpeckers (in Finnish with English summary). Fauna 26:1-6.

Wickman, B.E. 1965. Black-backed three-toed predation on Monochamus oregonensis. Pan-Pacific Entomologist 41(3):162-164.

Winterbottom, J.M. 1972. Note on altitude as a factor in bird distribution. Ostrich 43:133-134.

Yunick, R. P. 1985. A review of recent irruptions of the black-backed woodpecker and three-toed woodepcker in eastern North America. Journal of Field Ornithology 56:138-152.

APPENDIX 1

FIGURES AND TABLE

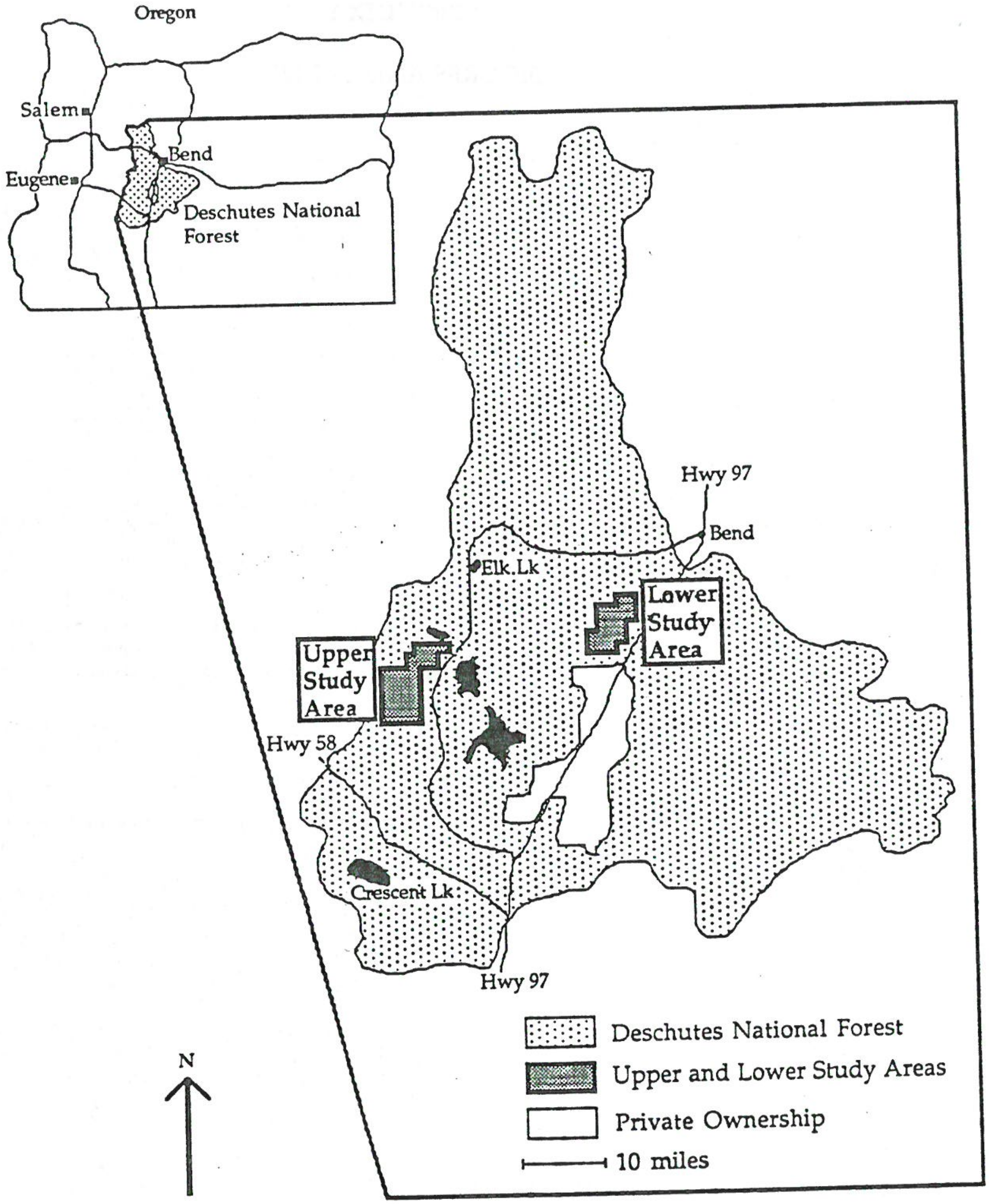
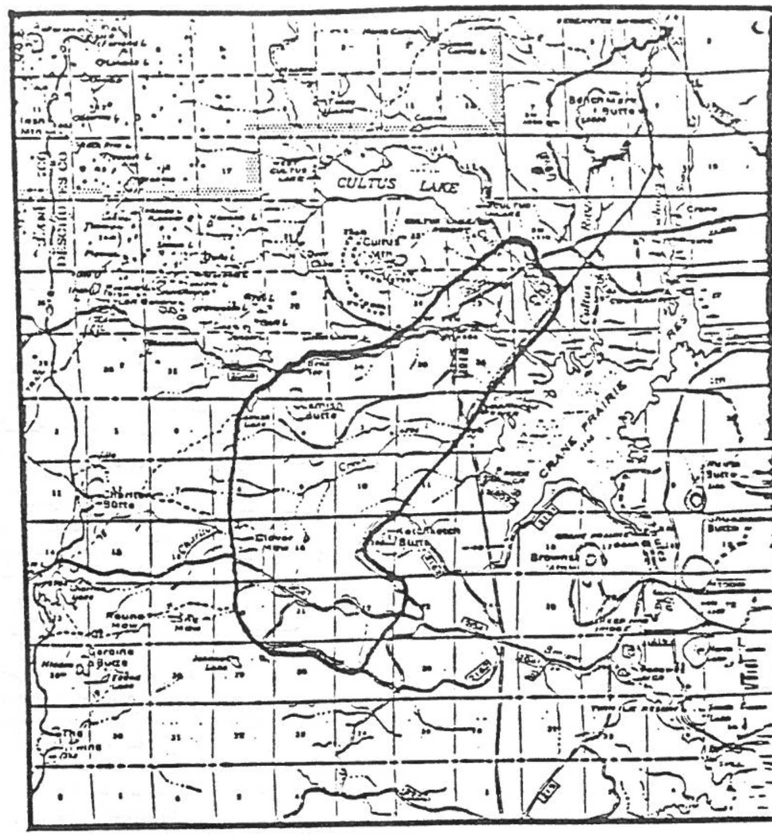


Figure 1. Location of the study areas for three-toed and black-backed woodpeckers, Deschutes National Forest, Oregon, 1986 and 1987.

A. Upper Study Area N

= 1 mi



B. Lower Study Area

= 1 mi

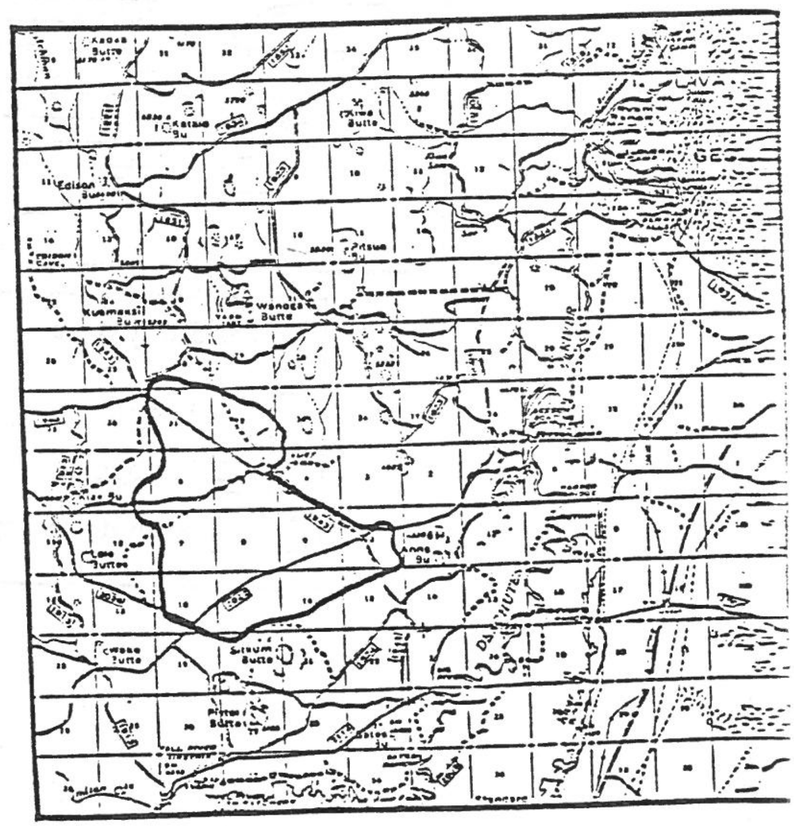


Figure 2. Maps of the (A) upper study area and (B) lower study area, Deschutes National Forest, Oregon, 1987.

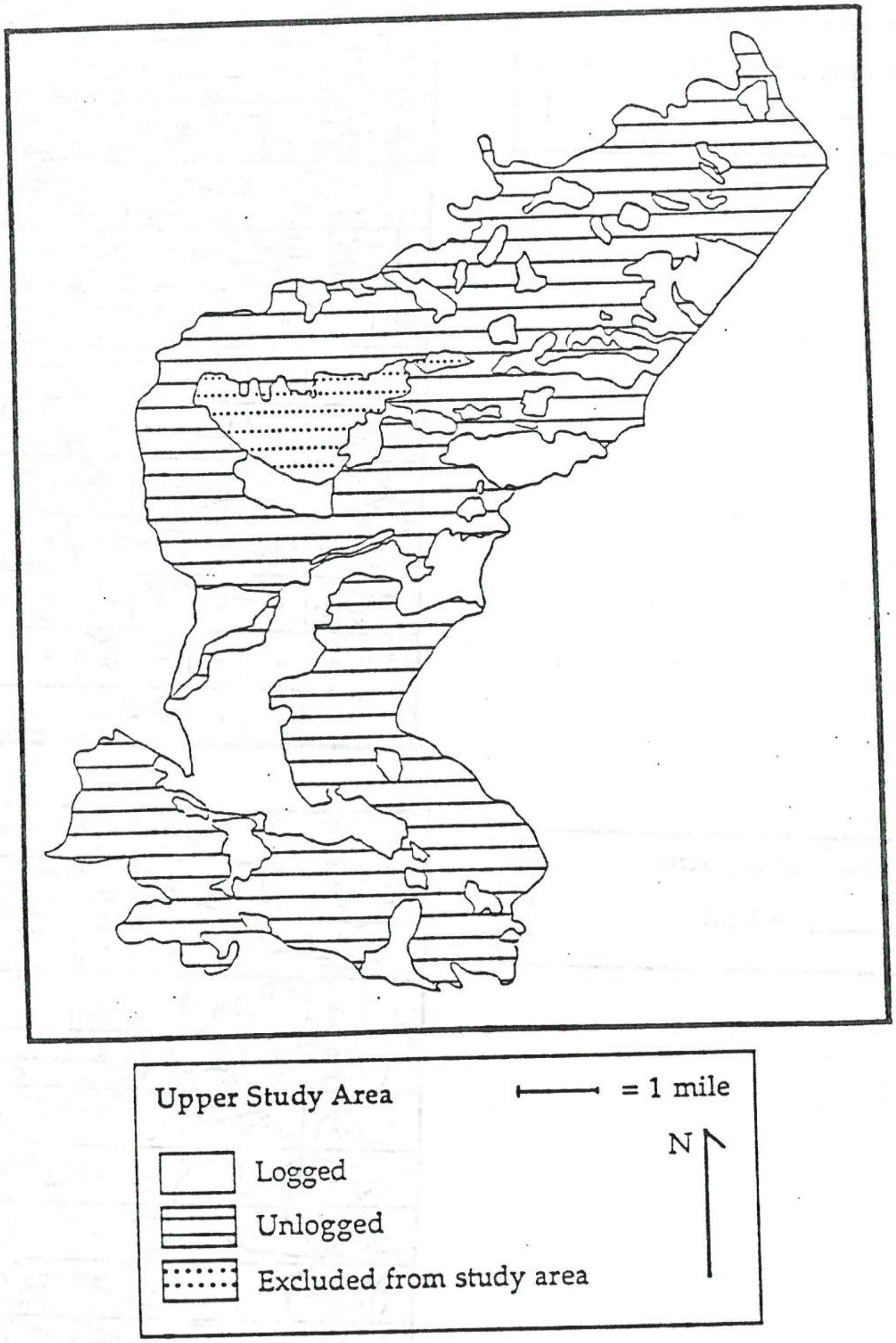


Figure 3. Map of the upper study area showing logged and unlogged areas, Deschutes National Forest, Oregon, 1987.

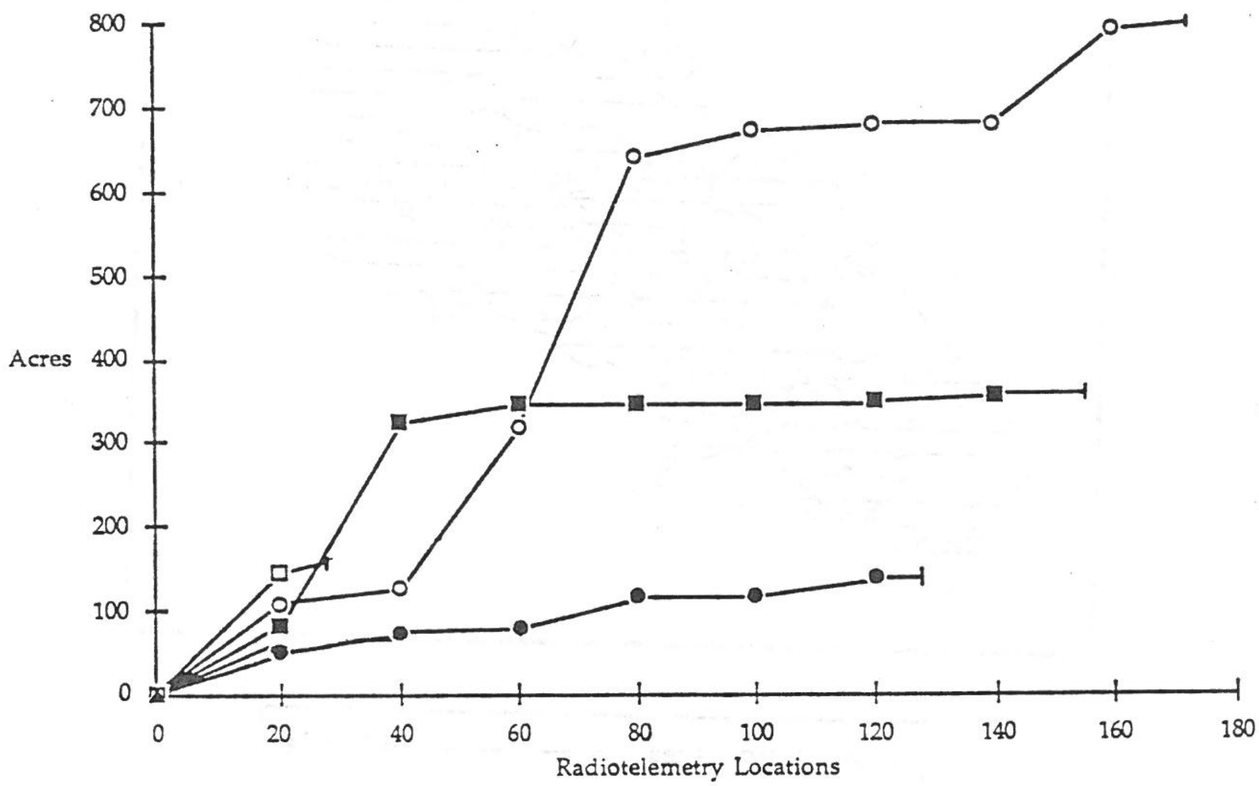


Figure 4. Area-observation curves for 5 radio-tagged three-toed woodpeckers during summer, 1987, Deschutes National Forest, Oregon.

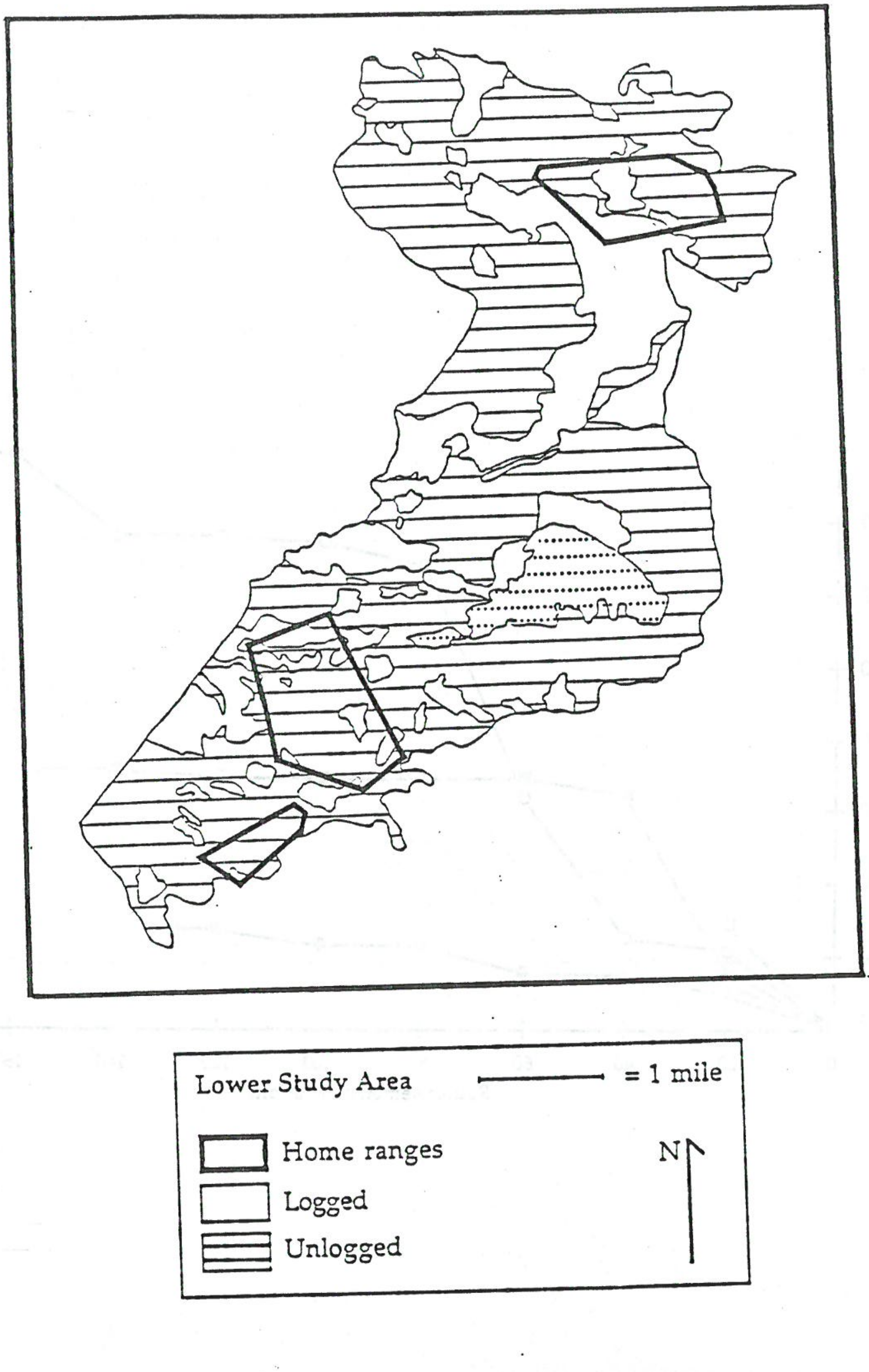


Figure 5. Map of the home ranges (minimum convex polygon) of 3 three-toed woodpeckers during summer 1987, on the upper study area, Deschutes National Forest, Oregon.

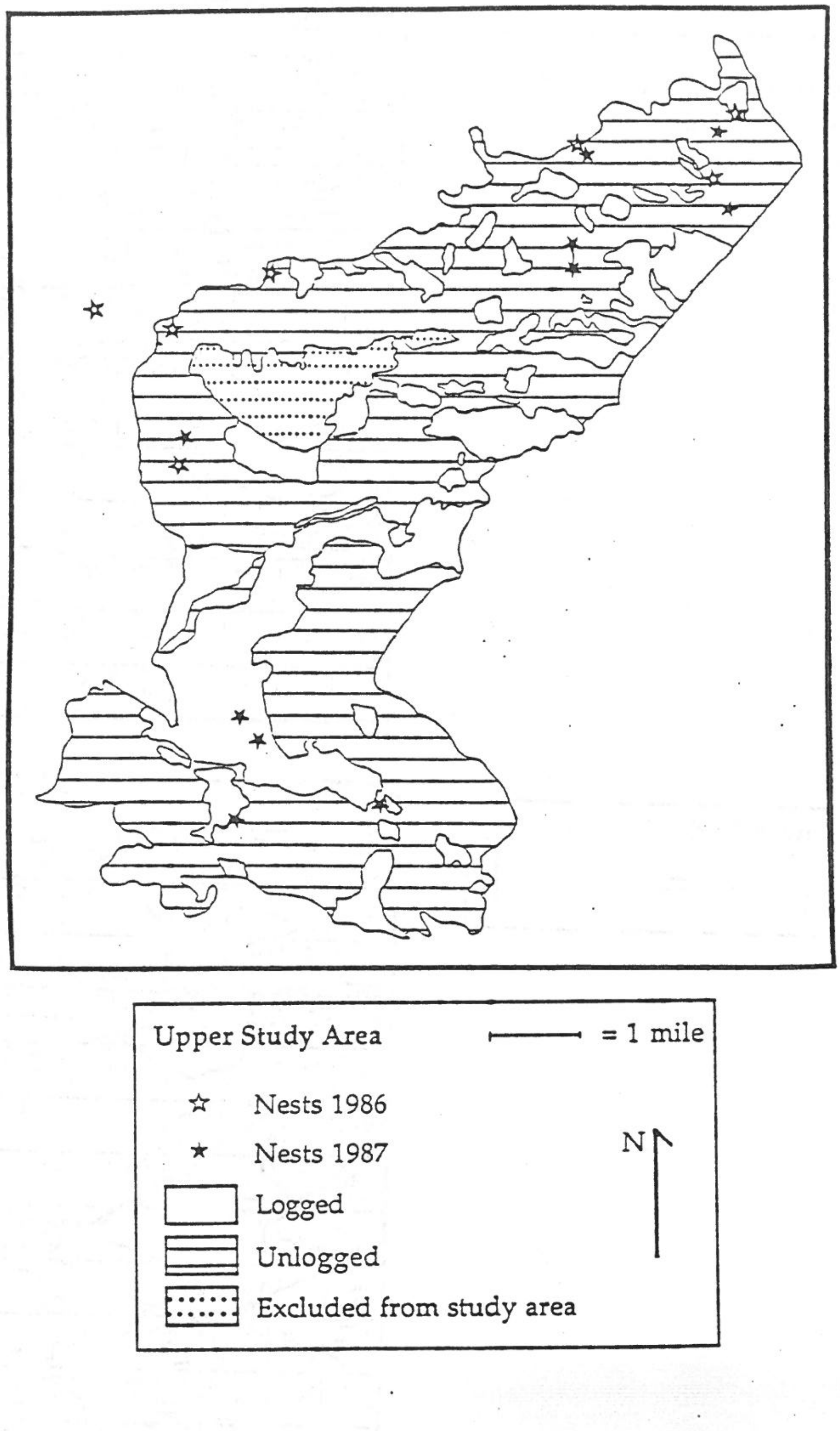
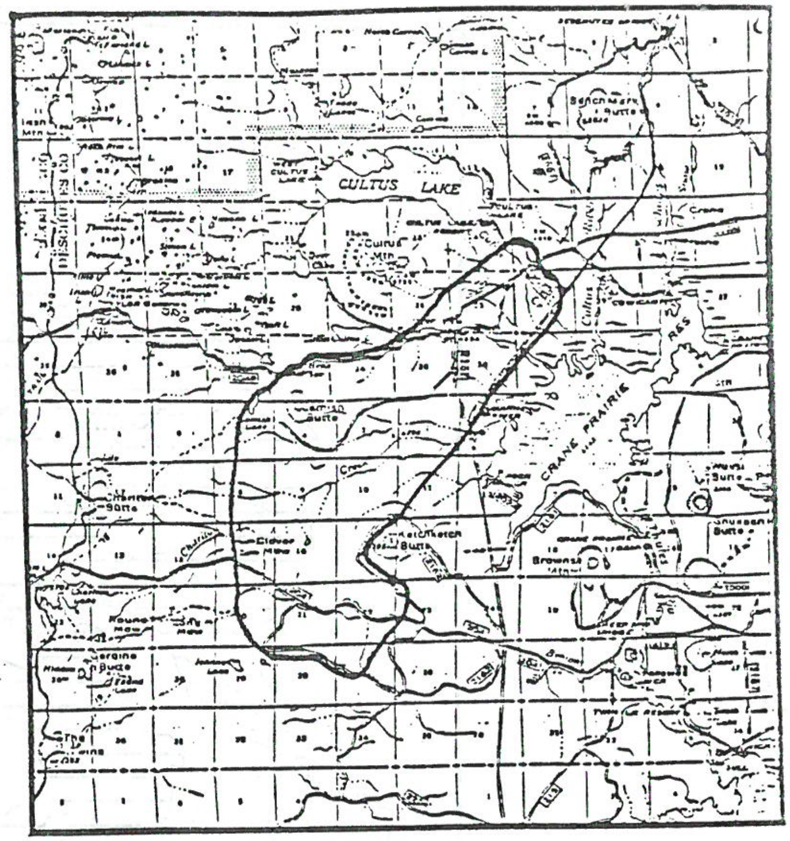


Figure 6. Map of the nests used by three-toed woodpeckers during 1986 and 1987 on the upper study area, Deschutes National Forest, Oregon.

A. Upper Study Area N

= 1 mi



B. Lower Study Area

= 1 mi

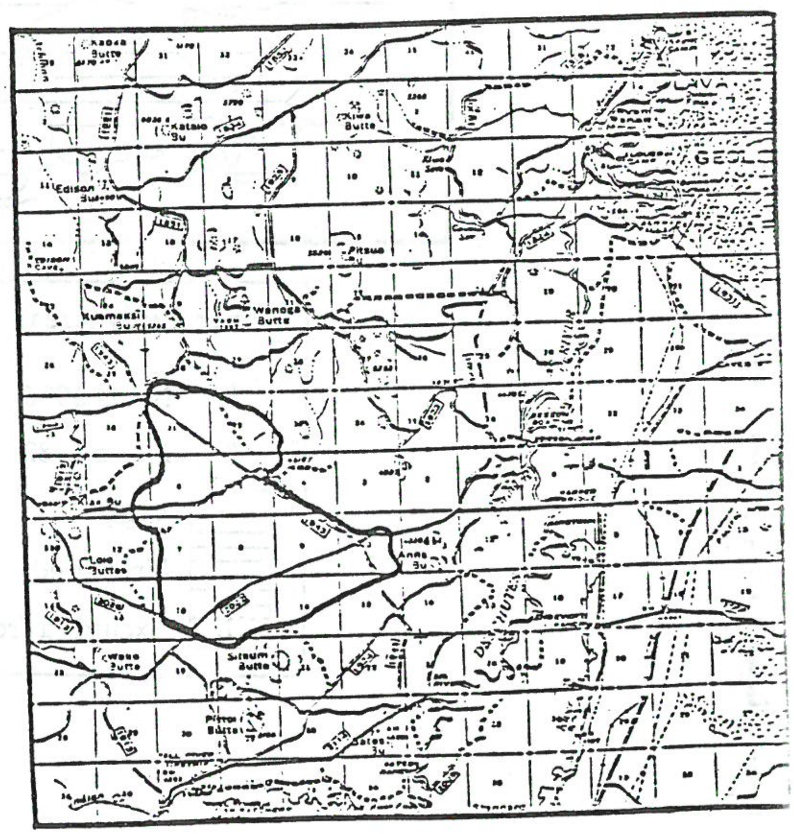


Figure 7. Maps of the (A) upper study area and (B) lower study area, Deschutes National Forest, Oregon, 1987.

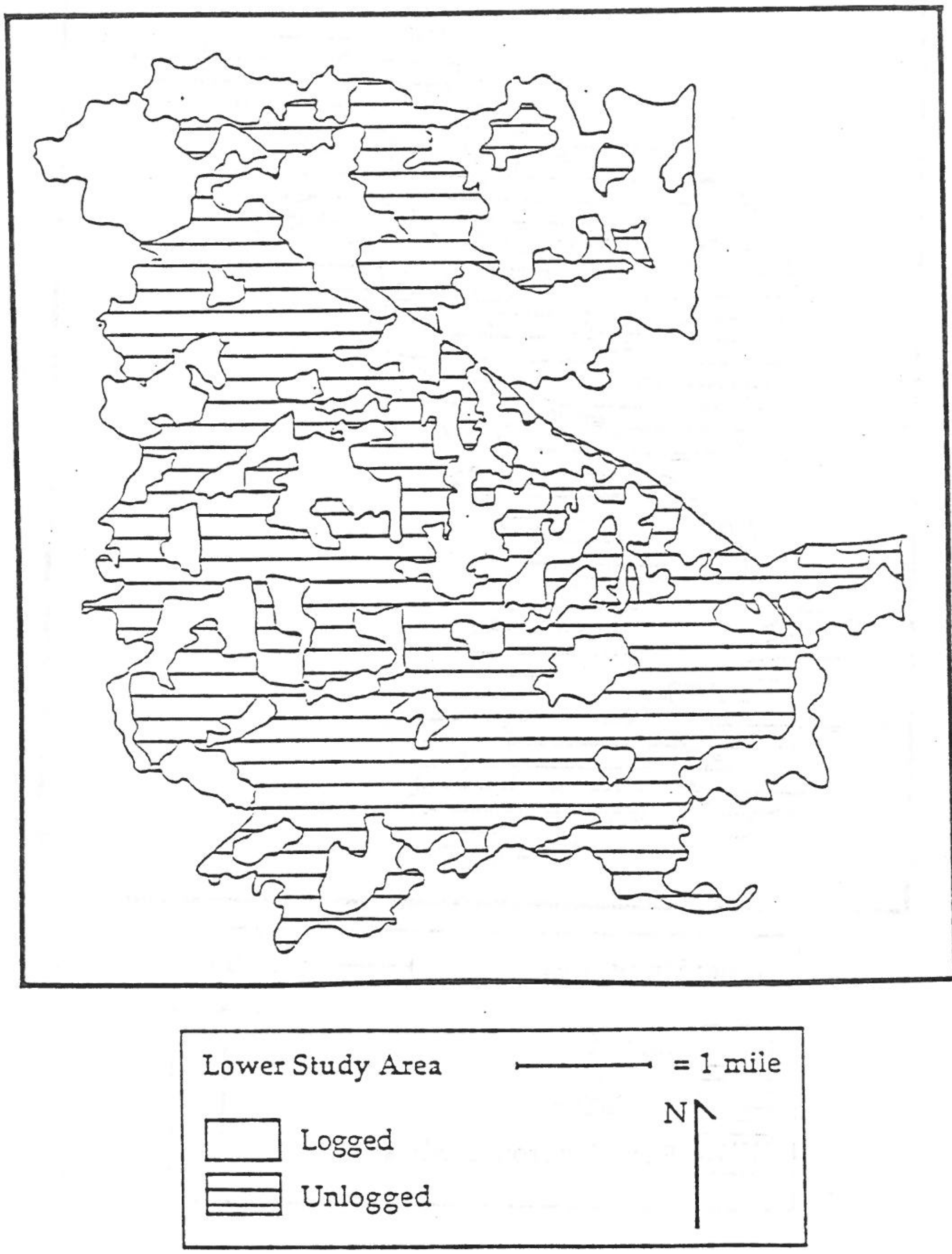


Figure 8. Map of the lower study area showing logged and unlogged areas, Deschutes National Forest, Oregon, 1987.

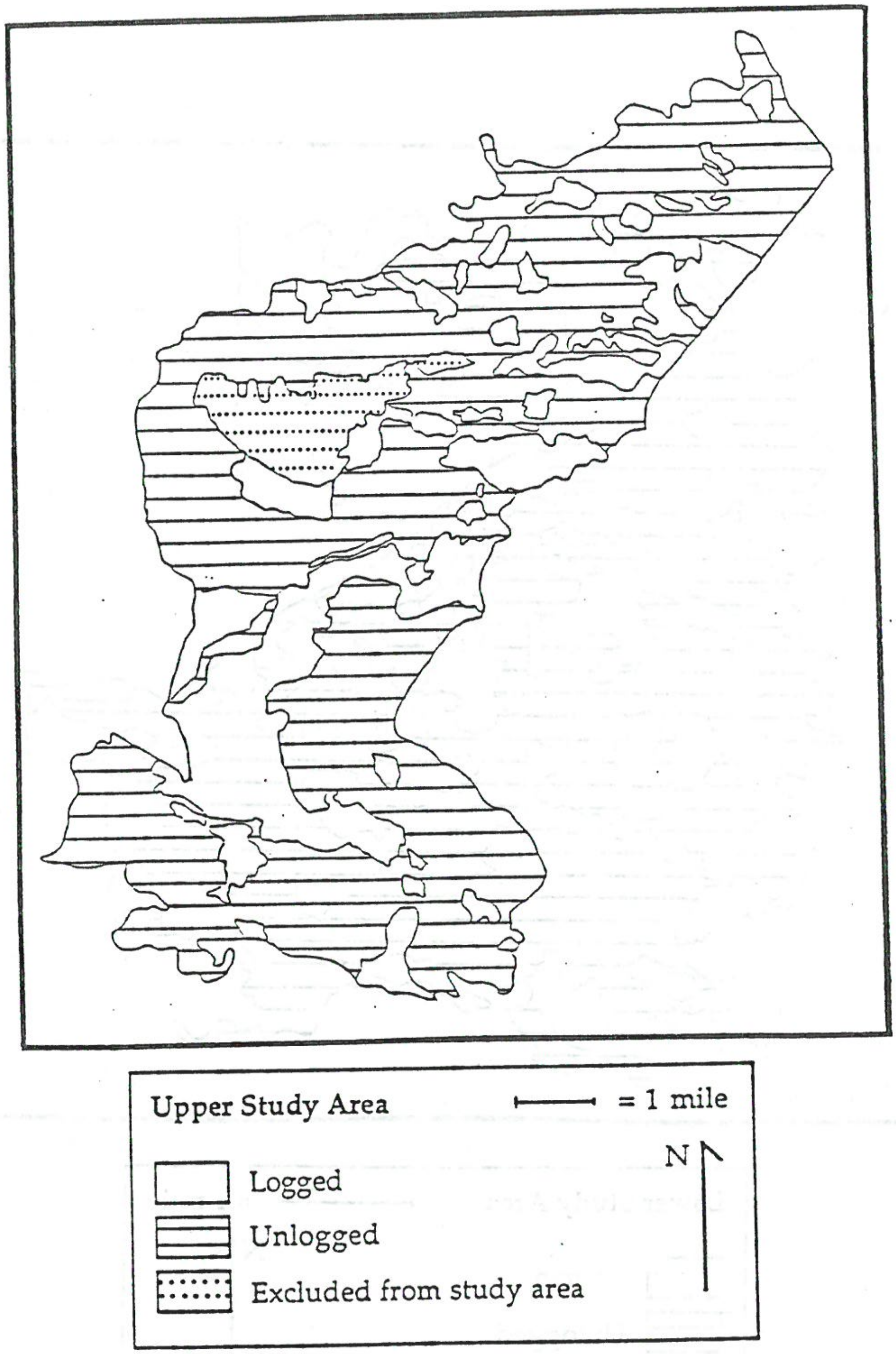


Figure 9. Map of the upper study area showing logged and unlogged areas, Deschutes National Forest, Oregon, 1987.

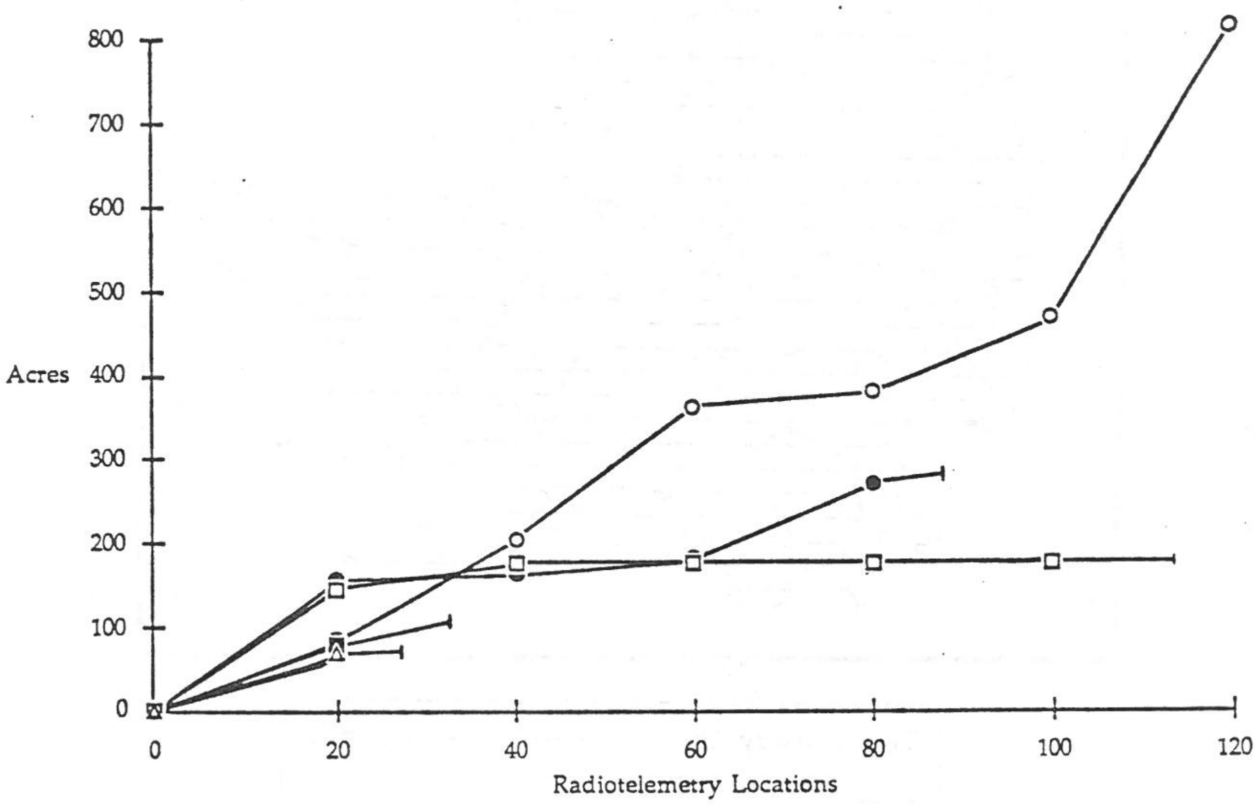


Figure 10. Area-observation curves for 6 radio-tagged black-backed woodpeckers, during summer 1987, Deschutes National Forest, Oregon.

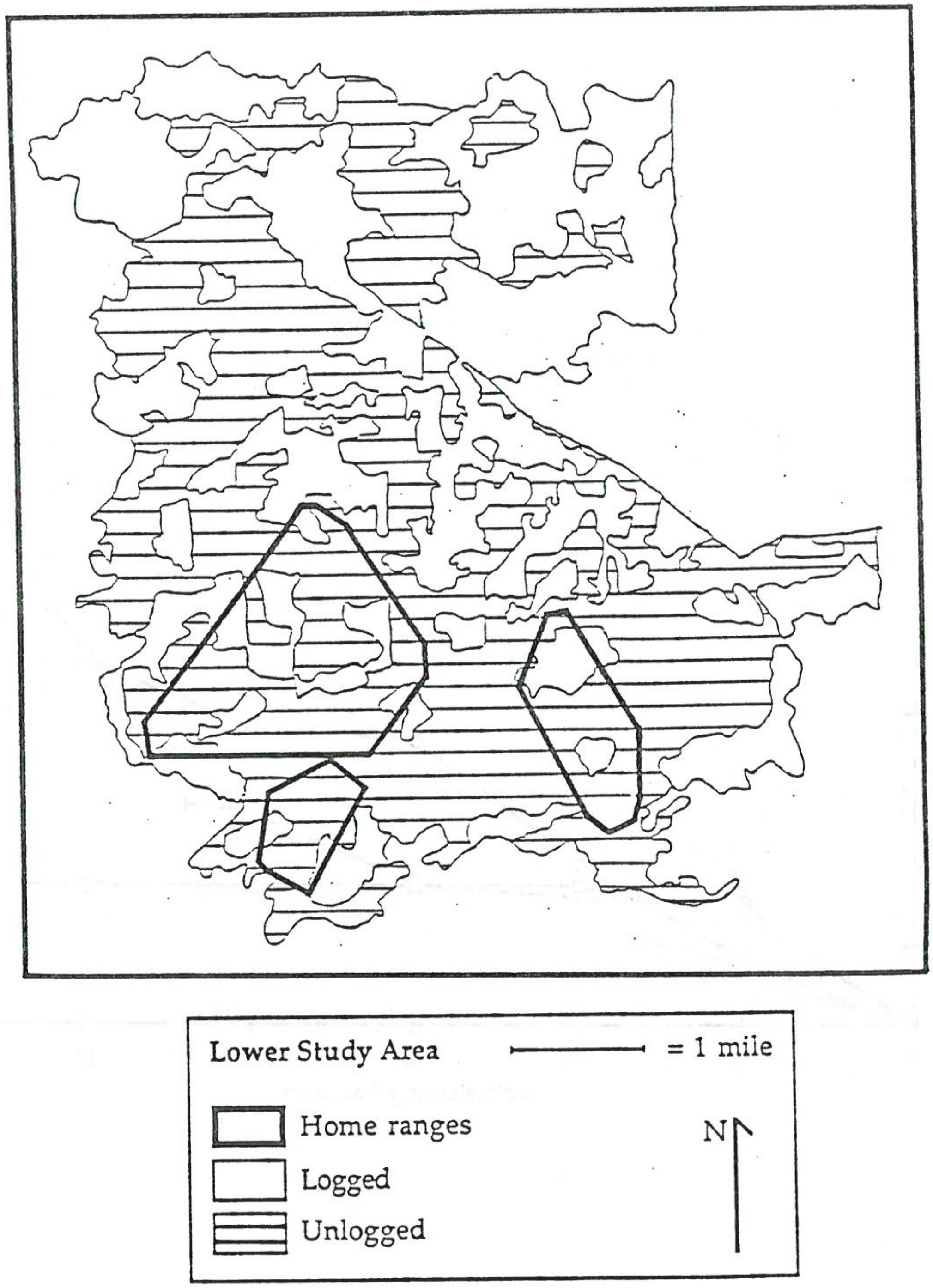


Figure 11. Map of the home ranges of 3 black-backed woodpeckers on the lower study area, Deschutes National Forest, Oregon.

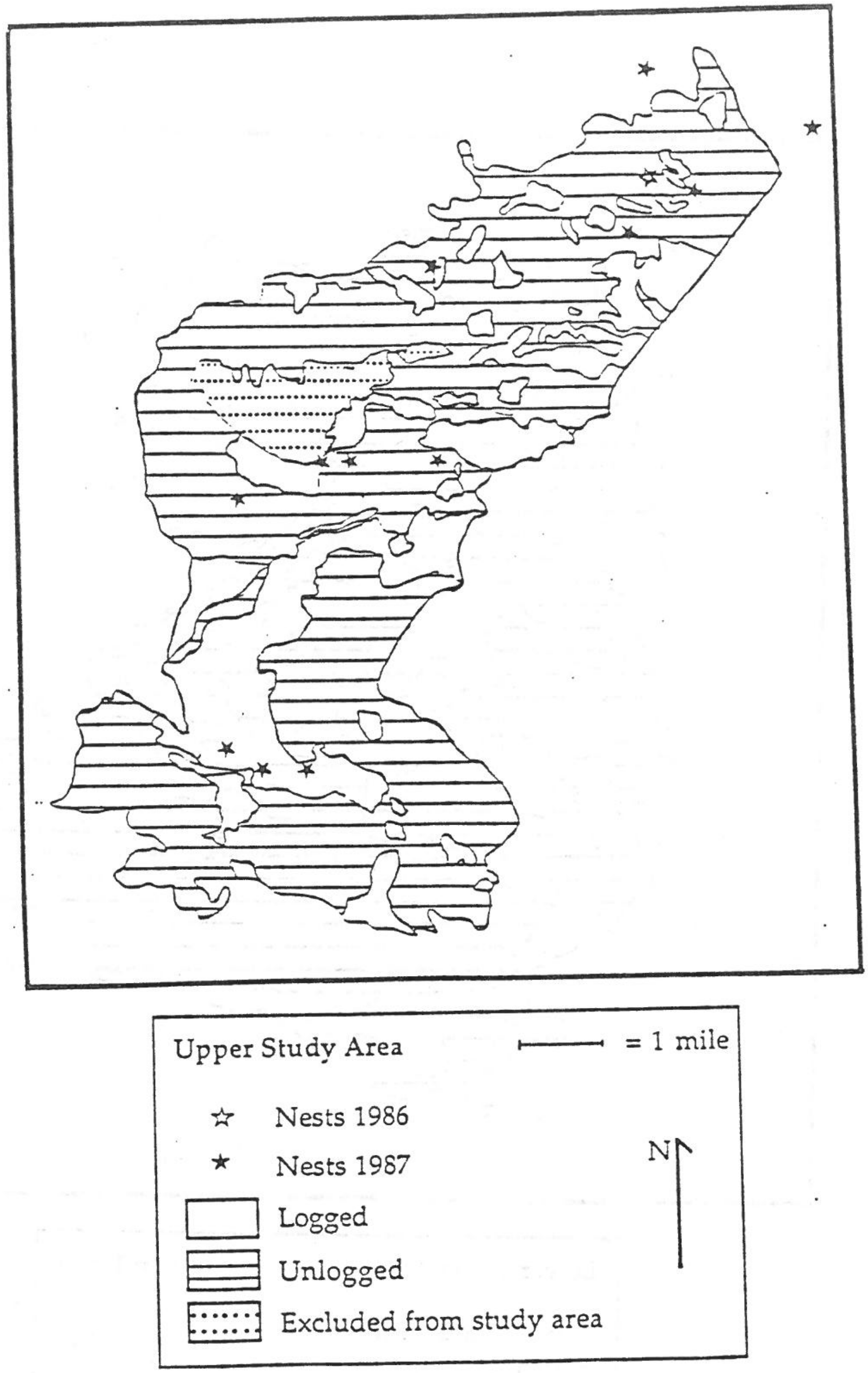


Figure 12. Map of the nests used by black-backed woodpeckers during 1986 and 1987 on the upper study area, Deschutes National Forest,

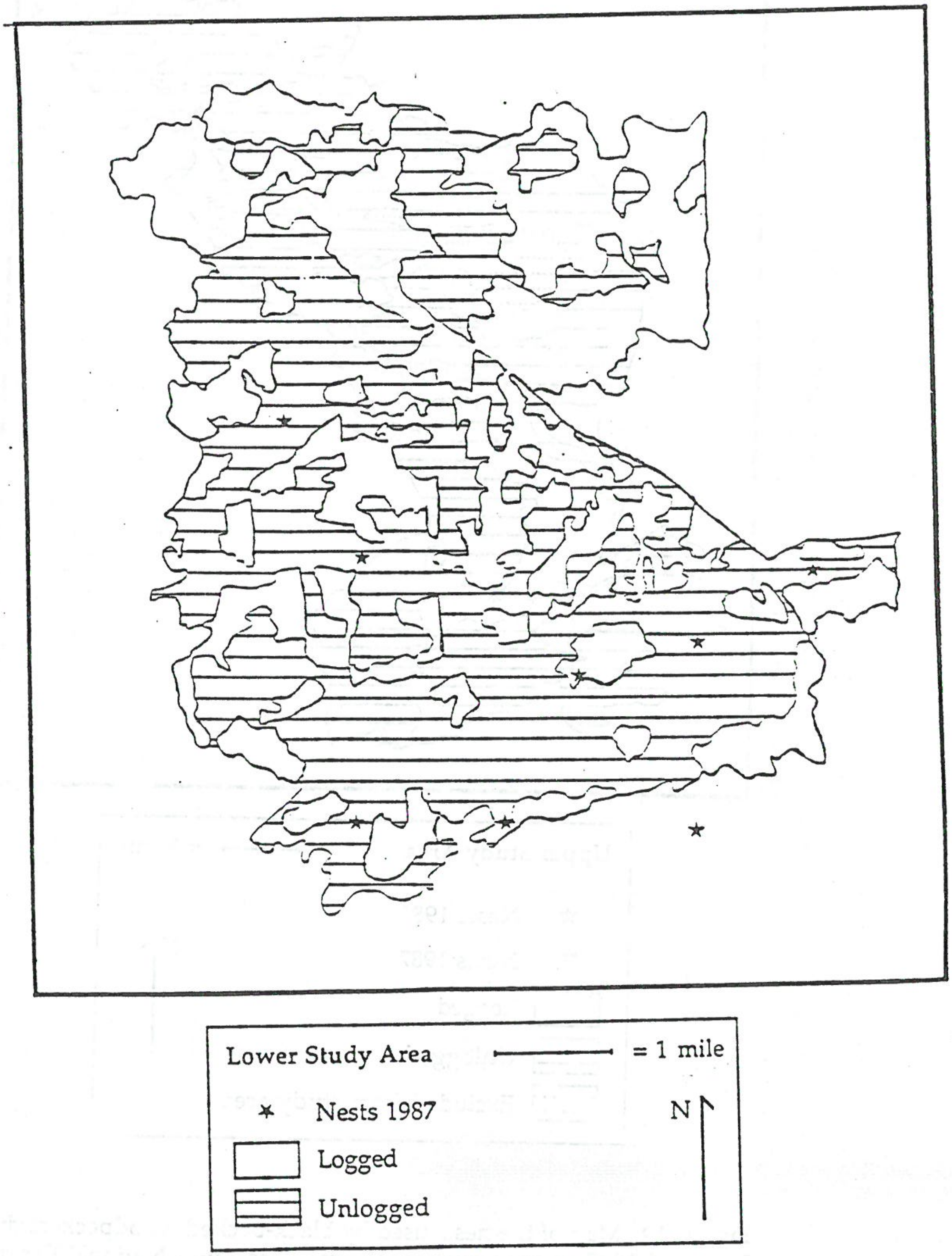


Figure 13. Map of the nests used by black-backed woodpeckers during 1987 on the lower study area, Deschutes National Forest, Oregon.

Table 1. Home range sizes (minimum convex polygon) of 3 three-toed woodpeckers during summer, Deschutes National Forest, Oregon, 1987.

Woodpeckers	Home Range (acres)	Number Locations	Sex (M/F)	Fledglings Present	Days Observed	Observation Range
2-cav	751	170	M	No	20	6 July -3 Sept
4-bird	351	152	M	No	10	9 July -3 Aug
Cultus	131	126	M	Yes	10	6 July -6 Aug
mean	411.0					
S.D.	314.3					

Table 2. Components of home ranges of 3 three-toed woodpeckers during summer, Deschutes National Forest, Oregon, 1987.

Size in Acres	Unlogged Acres (%)	Mature/Overmature Acres (%)
751	571 (76)	264 (35)
351	172 (49)	100 (29)
131	131 (100)	122 (93)

Table 3. Selection for habitat within home ranges by 3 three-toed woodpeckers during summer, Deschutes NF, Oregon , 1987. Forest habitat classes used in a proportion 50% greater than expected, based on availability, were interpreted as selected for, and classes used in proportions 50% less than expected were interpreted as selected against.

	Mature/Overmature		Logged	
	% of home range	% of locations	% of home range	% of locations
2-cav	35	70*	24	0**
4-bird	29	68*	51	5**
Cultus	93	96	0	0

* selection for habitat
**selection against habitat

Table 4. Selection for forest type within home ranges by 3 three-toed woodpeckers during summer, Deschutes NF, Oregon , 1987. Forest habitat classes used in a proportion 50% greater than expected, based on availability, were interpreted as selected for, and classes used in proportions 50% less than expected were interpreted as selected against.

	Lodgepole Pine		Mixed Conifer	
	% of home range	% of locations	% of home range	% of locations
2-cav	9	12	38	52
4-bird	5	60*	18	15
Cultus	34	14**	66	86

* selection for habitat
**selection against habitat

Table 5. Selection, within the study area, of habitat for home ranges by 3 three-toed woodpeckers, during summer, Deschutes NF,Oregon, 1987. Forest habitat classes used in a proportion 50% greater that expected, based on availability were interpreted as selected for, and classes used in proportions 50% less than expected were interpreted as selected against

Habitat description (from Deschutes NF TRI-system maps)	Percent available on study area	Percent of locations in habitat(1)	Number of woodpeckers	
			Selected for habitat	Selected against habitat
Single-storied seedlings, saplings or immature poles	16	0, 0, 4	0	3
Single-storied small sawtimber	11	0, 4, 28	1	2
Single-storied mature and overmature sawtimber	33	68, 70, 96	3	0
Multi-storied, viable and nonviable understory	11	0, 0, 4	0	3
Plantations and cuts	27	0, 0, 5	0	3

(1) Percent use of habitat classes by 3 radio-tagged woodpeckers.

Table 6. Selection, within the study area, of habitat for home ranges, by 3 three-toed woodpeckers, during summer, Deschutes NF, Oregon, 1987. Forest habitat classes used in proportions 50% greater that expected, based on availability, were interpreted as selected for, and classes used in proportions 50% less than expected, as selected against.

Habitat description (from Deschutes NF TRI-system maps)(1)	Percent available on study area(2)	Percent of locations in habitat(3)	Number of woodpeckers: Selected for habitat	Number of woodpeckers: Selected against habitat	Number of woodpeckers: No selection
Lodgepole Pine	30	13, 15, 70	1	2	0
Mixed Conifer	70	86, 85, 30	0	1	2

(1) Logged areas were excluded from this analysis.
(2) Only habitat classes more than 5% of study area were included.
(3) Percent use of habitat classes by 3 radio-tagged woodpeckers.

Table 7. Selection of habitat for nesting by 16 pairs of three-toed woodpeckers, during 1986 and 1987, Deschutes NF, Oregon. Forest habitat classes used in a proportion 50% greater that expected, based on availability, were interpreted as selected for, and classes used in proportions 50% less than expected, as selected against.

Habitat description (from Deschutes N F TRI-system maps)	Percent available on study area	Percent of nests in habitat	Selection for habitat	Selection against habitat	No selection
Single-storied seedlings, saplings or immature poles	16	25			X
Single-storied small sawtimber	11	13			X
Single-storied mature and overmature sawtimber	33	19			X
Multi-storied, viable and nonviable understory	11	13			X
Plantations and cuts	28	31			X

Table 8. Selection of habitat for nesting by 16 pairs of three-toed woodpeckers, 1986 and 1987, Deschutes NF, Oregon. Forest habitat classes used in a proportion 50% greater that expected, based on availability, were interpreted as selected for, and classes used in proportions 50% less than expected, as selected against.

Habitat description (from Deschutes NF TRI-system maps)(1)	Percent available on study area(2)	Percent of nests in habitat	Selection for habitat	Selection against habitat	No selection
Lodgepole Pine	30	73	X		
Mixed Conifer	70	27		X	

(1) Logged areas were excluded from this analysis.
(2) Only habitat classes more than 5% of study area were included.

Table 9. Selection of habitat for foraging (n=401 locations) by 3 three-toed woodpeckers during summer, 1987, Deschutes NF, Oregon. Forest habitat classes used in a proportion 50% greater that expected, based on availability, were interpreted as selected for, and classes used in proportions 50% less than expected were interpreted as selected against.

Habitat description (from Deschutes NF TRI-system maps)	Percent available on study area(1)	Percent of locations in habitat(2)	Number of woodpeckers: Selected for habitat	Number of woodpeckers: Selected against habitat
Single-storied seedlings, saplings or immature poles	16	0, 0, 4	0	3
Single-storied small sawtimber	11	0, 5, 30	1	2
Single-storied mature and overmature sawtimber	33	66, 91, 96	3	0
Multi-storied, viable and nonviable understory	11	0, 0, 4	0	3
Plantations and cuts	28	0, 0, 0	0	3

(1) Only classes more than 5% of study area were included.
(2) Percent use of habitat classes by 3 radio-tagged woodpeckers.

Table 10. Selection of habitat for foraging (n=401 locations) by 3 three-toed woodpeckers during summer, 1987, Deschutes NF, Oregon. Habitat classes used in a proportion 50% greater that expected, based on availability, were interpreted as selected for, and classes used in proportions 50% less than expected, as selected against.

Habitat description (from Deschutes NF TRI-system maps)(1)	Percent available on study area(2)	Percent of locations in habitat(3)	Number of woodpeckers: Selected for habitat	Selected against habitat	No selection
Lodgepole Pine	30	16, 16, 73	1	0	2
Mixed Conifer	70	84, 84, 27	0	1	2

(1) Logged areas were excluded from this analysis.
(2) Only habitat classes more than 5% of study area were included.
(3) Percent use of forest habitat classes by 3 radio-tagged woodpeckers.

Table 11. Selection of habitat for roosts (n=18), by 4 three-toed woodpeckers, during summer, 1987, Deschutes NF, Oregon. Habitat classes used in a proportion 50% greater that expected, based on availability, were interpreted as selected for, and classes used in proportions 50% less than expected were interpreted as selected against.

Habitat description (from Deschutes NF TRI-system maps)	Percent available on study area(1)	Percent of roosts in habitat	Selection for habitat	Selection against habitat	No selection
Single-storied seedlings, saplings or immature poles	16	0		X	
Single-storied small sawtimber	11	11			X
Single-storied mature and overmature sawtimber	33	83	X		
Multi-storied, viable and nonviable understory	11	0		X	
Plantations and cuts	28	6		X	

(1) Only classes more than 5% of study area were included.

Table 12. Selection of habitat for roosts (n=18), by 4 three-toed woodpeckers, during summer, 1987, Deschutes NF, Oregon. Habitat classes used in a proportion 50% greater that expected, based on availability, were interpreted as selected for, and classes used in proportions 50% less than expected were interpreted as selected against.

Habitat description (from Deschutes NF TRI-system maps)(1)	Percent available on study area	Percent of roosts in habitat	Selected for habitat	Selected against habitat	No selection
Lodgepole Pine	30	0		X	
Mixed Conifer	67	76			X
Mountain Hemlock	3	24	X		

(1) Logged areas were excluded from this analysis.

Table 13. Home range sizes (minimum convex polygon) of 3 black-backed woodpeckers during summer, Deschutes National Forest, Oregon, 1987.

Woodpeckers	Home range (acres)	Number Locations	Sex (M/F)	Fledglings Present	Days Observed	Observation Range
75	810	124	M	No	9	18 June-19 July
Cut	303	86	F	Yes	7	16 June-11 July
Mys	178	112	M	No	12	9 June-14 July
Mean	431.7					
S.D.	333.9					

Table 14. Components of home ranges of 3 black-backed woodpeckers during summer, Deschutes NF, Oregon, 1987.

Size in Acres	Unlogged Acres (%)	Mature/Overmature Acres (%)
810	575 (71)	478 (59)
307	224 (73)	210 (68)
178	148 (83)	148 (83)

Table 15. Characteristics of home ranges (minimum convex polygon) and habitat used by 3 black-backed woodpeckers, during summer, Deschutes National Forest, Oregon, 1987. Forest habitat classes used in a proportion 50% greater than expected, based on availability, were interpreted as selected for and classes used in proportions 50% less than expected were interpreted as selected against.

	Mature/Overmature		Not Logged	
	% of home range	% of locations	% of home range	% of locations
1	59	78	82	99
2	68	97	73	99
3	83	99	83	98

* selection for habitat
**selection against habitat

Table 16. Selection for home range habitat, within the lower study area, by 3 black-backed woodpeckers, during summer, 1987, Deschutes NF, Oregon. Forest habitat classes used in a proportion 50% greater than expected, based on availability, were interpreted as selected for, and classes used in proportions 50% less than expected were interpreted as selected against.

Habitat description (from Deschutes NF TRI-system maps)	Percent available on study area(1)	Percent of locations in habitat(2)	Number of woodpeckers	
			Selected for habitat	Selected against habitat
Single-storied seedlings, saplings or immature poles	7	0, 0, 0	0	3
Single-storied small sawtimber	11	0, 2, 2	0	3
Single-storied mature and overmature sawtimber	39	78, 97, 99	3	0
Plantations and Cuts	33	19, 2, 1	0	3

(1) Only classes more than 5% of study area were included.
(2) Percent use of habitat classes by individual birds.

Table 17. Selection of habitat for nesting by 8 pairs of black-backed woodpeckers on the lower study area, during 1987, Deschutes NF, Oregon. Habitat classes used in a proportion 50% greater than expected, based on availability, were interpreted as selected for, and classes used in proportions 50% less than expected, as selected against.

Habitat description (from Deschutes NF TRI-system maps)	Percent available on study area	Percent of nests in habitat	Selection for habitat	Selection against habitat	No selection
Single-storied seedlings, saplings or immature poles	7	0			X
Single-storied small sawtimber	11	0			X
Single-storied mature and overmature sawtimber	39	88	X		
Plantations and cuts	42	12			X

Table 18. Selection of habitat for nesting by 12 pairs of black-backed woodpeckers on the upper study area, during 1986 and 1987, Deschutes NF, Oregon. Habitat classes used in a proportion 50% greater that expected, based on availability, were interpreted as selected for, and classes used in proportions 50% less than expected, as selected against.

Habitat description (from USDA Deschutes NF TRI-system maps)	Percent available on study area	Percent of nests in habitat	Selection for habitat	Selection against habitat	No selection
Single-storied seedlings, saplings or immature poles	16	17			X
Single-storied small sawtimber	11	0		X	
Single-storied mature and overmature sawtimber	33	25			X
Multi-storied, viable and nonviable understory	11	25	X		
Plantations and cuts	28	33			X

Table 19. Selection of habitat for nesting by 8* of pairs black-backed woodpeckers, on the upper study area, during 1986 and 1987, Deschutes NF, Oregon. Habitat classes used in a proportion 50% greater than expected, based on availability, were interpreted as selected for, and classes used in proportions 50% less than expected, as selected against.

Habitat description (from Deschutes NF TRI-system maps)(1)	Percent available on study area(2)	Percent of nests in habitat	Selection for habitat	Selection against habitat	No selection
Lodgepole Pine	30	38			X
Mixed Conifer	70	62			X

(1) Logged areas were excluded from this analysis.
(2) Only habitat classes more than 5% of study area were included.

Table 21. Selection of habitat for roosts (n=13), by 3 black-backed woodpeckers on the lower study area, during summer,1987, Deschutes NF, Oregon. Habitat classes used in a proportion 50% greater than expected, based on availability, were interpreted as selected for, and classes used in proportions 50% less than expected were interpreted as selected against.

Habitat description (from Deschutes NF TRI-system maps)	Percent available on study area(1)	Percent of locations in habitat	Number of woodpeckers: Selected for habitat	Number of woodpeckers: Selected against habitat
Single-storied seedlings, saplings or immature poles	7	0	0	3
Single-storied small sawtimber	11	0	0	3
Single-storied mature and overmature sawtimber	39	100	3	0
Plantations and cuts	33	11	0	3

(1) Only classes more than 5% of study area were included.

Table 20. Selection by 3 black-backed woodpeckers for foraging habitat on the lower study area (n=190 locations), during summer, Deschutes NF, Oregon, 1987. Forest habitat classes used in a proportion 50% greater that expected, based on availability,were interpreted asselected for, and classes used in proportions 50% less than expected were interpreted as selected against.

Habitat description (from Deschutes NF TRI-system maps)	Percent available on study area(1)	Percent of locations in habitat(2)	Number of woodpeckers	
			Selected for habitat	Selected against habitat
Single-storied seedlings, saplings or immature poles	7	0, 0, 0	0	3
Single-storied small sawtimber	11	0, 3, 2	0	3
Single-storied mature and overmature sawtimber	39	79, 97, 100	3	0
Plantations and cuts	36	19, 0, 0	0	3

(1) Only classes more than 5% of study area were included.
(2) Percent use of habitat classes by individual birds.